

VOLUME XXXV

NUMBER 3

JOURNAL
OF THE
ARNOLD ARBORETUM
HARVARD UNIVERSITY

EDITORIAL BOARD

C. E. KOBUSKI, *Editor*

I. W. BAILEY

I. M. JOHNSTON

R. A. HOWARD

KARL SAX

JULY, 1954



PUBLISHED BY

THE ARNOLD ARBORETUM OF HARVARD UNIVERSITY

JAMAICA PLAIN, MASS.

1954

THE JOURNAL OF THE ARNOLD ARBORETUM

Published quarterly by the Arnold Arboretum of Harvard University.

Subscription price \$7.00 per year.

Vols. I–XI out of print. Vols. XII (1931), XIII (1932): Price \$3.00 each; Vols. XIV (1933) — XXVIII (1947): Price \$4.00 each; Vols. XXIX (1948) — XXXV (1954): Price \$7.00 each.

Subscriptions and remittances should be addressed to the ARNOLD ARBORETUM, JAMAICA PLAIN, MASSACHUSETTS.

CONTENTS OF NO. 3

THE CYPERACEAE COLLECTED IN NEW GUINEA BY L. J. BRASS, IV. With one plate and two text-figures. By <i>S. T. Blake</i>	203
PREVERNAL LEAFING OF ASPEN IN UTAH MOUNTAINS. With two plates. By <i>Walter P. Cottam</i>	239
THE CONTROL OF TREE GROWTH BY PHLOEM BLOCKS. With one plate. By <i>Karl Sax</i>	251
CRYPTOGAMS OF THE 1948 ARCHBOLD CAPE YORK (QUEENSLAND) EXPEDITION. By <i>P. Bibby</i>	260
ADDITIONAL NOTE ON NOTHOFAGUS. With one text-figure. By <i>C. G. G. J. van Steenis</i>	266
NEW ZEALAND CONIFERS. With one plate. By <i>Vivienne Dellow Cassie</i>	268

*Vol. XXXV, No. 2, including pages 87–202, with eight plates,
was issued April 15, 1954.*

Entered as second class matter April 4, 1940, at the post office at Boston, Massachusetts, under the Act of August 24, 1912.

JOURNAL OF THE ARNOLD ARBORETUM

VOL. XXXV

JULY 1954

NUMBER 3

THE CYPERACEAE COLLECTED IN NEW GUINEA BY L. J. BRASS, IV.*

S. T. BLAKE

With one plate and two text-figures

THIS PAPER COMPLETES the account of the specimens collected by Mr. L. J. Brass during the Archbold Expeditions between 1933 and 1939. As in the previous contributions (Jour. Arnold Arb. 28: 99–116, 207–229. 1947; 29: 90–102. 1948), some other specimens are cited. To the acknowledgements made in earlier contributions, I wish to add my thanks to Prof. H. Humbert, Dr. O. Hagerup, Dr. A. Hässler and Dr. H. J. Lam for the loan of types and other material from the herbaria of Paris, Copenhagen, Lund and Leiden respectively, and to Mr. R. H. Anderson for the loan of all specimens of *Scleria* in the Sydney Herbarium.

The genera treated here are *Scirpus*, *Fimbristylis*, *Scleria*, *Diplacrum* and *Uncinia*, and there are some additional notes on genera previously treated. The treatment of the different genera is somewhat unequal, particularly as to the citation of synonyms, but in all cases it is based on fairly extensive revisional work on the Malaysian and Australasian species. The delayed appearance of this paper is due partly to the necessity of examining certain types before some groups of species could be determined satisfactorily.

Herbaria are indicated by the following abbreviations: Brisbane, BRI; Canberra, CANB; Copenhagen, c; Leiden, L; Lund, LD; Melbourne, MEL; Paris, P; Sydney, NSW.

Scirpus Linnaeus

Scirpus ternatanus Reinw. ex Miq. Fl. Ind. Bat. 3: 307. 1859; Kükenth. Bot. Jahrb. 69: 259. 1938; Ohwi, Bot. Mag. Tokyo 56: 204. 1942.

Scirpus chinensis Munro in Seem. Bot. Voy. Herald 423. 1857; Valck. Suring. Nova Guin. Bot. 8: 705. 1912; Ridl. Trans. Linn. Soc. II, Bot. 9: 242. 1926; non Osbeck 1753.

* Botanical Results of the Richard Archbold Expeditions. See Jour. Arnold Arb. 29: 90–102. 1948.

NETHERLANDS NEW GUINEA: Bele R., 18 km. NE. of Lake Habbema, *Brass 11472*, Nov. 1938, alt. 2200 m., large clumps in moist situations on grassy, formerly cultivated slopes; Balim R., *Brass 11677*, Dec. 1938, alt. 1600 m., colonizing loose sand and stones from a landslip; 9 km. NE. of Lake Habbema, *Brass 10993*, Oct. 1938, alt. 2650 m., plentiful in *Equisetum* cover on landslips, large clumps \pm 75 cm. high; 9 km. NE. of Lake Habbema, *Brass 10883*, Oct. 1938, alt. 2650 m., open banks of a stream in forest.

The range of this species extends north and west through Malaysia to India, China and Japan.

? *Scirpus strobolinus* Roxb. Hort. Beng. 6. 1814, *nomen nudum*, Fl. Ind. ed. Carey & Wall. 1: 223. 1820, Fl. Ind. ed. Carey 1: 219. 1832.

PAPUA: Western Division: Gaima, Lower Fly R. (east bank), *Brass 8304*, Nov. 1936, loose sand on open foreshores, not common.

The specimens are in flower only and the identification is rather uncertain, though they appear to belong here rather than to *S. maritimus* L., *S. fluviatilis* A. Gray or *S. paludosus* A. Nels. *Scirpus strobolinus* is otherwise known from different parts of Asia, extending south to Assam and Pegu.

Scirpus mucronatus L. Sp. Pl. 50. 1753; K. Schum. in K. Schum. & Lauterb. Fl. Deutsch. Schutzgeb. Südsee 195. 1901; Valck. Suring. Nova Guin. Bot. 8: 704. 1912; Kükenth. Bot. Jahrb. 59: 51. 1924, 69: 259. 1938.

NETHERLANDS NEW GUINEA: Balim R., *Brass 11804*, Dec. 1938, alt. 1600 m., occasional in ditches and grassy pools.

PAPUA: Western Division: Junction of Black and Palmer Rivers, *Brass 6943*, June 1936, common on silt-covered gravel banks in river (det. Uittien). Central Division: Urunu, Vanapa Valley, *Brass 4810*, July-Aug. 1933, alt. 1900 m., plentiful in small swamps on open slopes of valley; Koitaki, *Carr 12283*, May 1935, alt. 1500 ft., swamp in open savannah land, c. 4 ft. tall (herb. Canberra).

A species widely spread over the warmer parts of the Eastern Hemisphere.

Scirpus clemensiae (Kükenth.) Ohwi, Bot. Mag. Tokyo 56: 203. 1942.

Scirpus clemensiae (Kükenth.) Kükenth. Mitteil. Thüring. Bot. Ver. N. F. 50: 13. 1943.

Scirpus mucronatus L. subsp. *clemensii* Kükenth. Bot. Jahrb. 69: 259. 1939.

NETHERLANDS NEW GUINEA: Lake Habbema, *Brass 9069*, August 1938, alt. 3225 m., plentiful in sandy marginal shallows of lake, tufts 40-60 cm. high; Lake Habbema, *Brass 9439*, August 1938, alt. 3225 m., abundant in marginal shallows of lake.

Known also from North-East New Guinea, whence it was originally de-

scribed. The binary combination was made independently by Ohwi and Kükenthal. Ohwi spelled the epithet *Clemensii*, as published in the ternary combination. When Kükenthal made the binary combination, he cited "Scirpus Clemensiae Kükenth., comb. nova.—*Sc. mucronatus* L. subsp. *Clemensii* Kükenth. in Bot. Jahrb. 69.2. (1938) 259." It would appear that the spelling *Clemensii* in the first paper was "an unintentional orthographic error" which was corrected in the later paper, as permitted by Art. 70 of the International Rules, and I have adopted the emended spelling. The plant was evidently dedicated to Mrs. M. S. Clemens.

Scirpus validus Vahl, Enum. 2: 268. 1806.

PAPUA: Western Division: Gaima, Lower Fly R. (east bank), *Brass 8305*, Nov. 1936, gregarious on open sandy foreshores.

New for Papua; widely spread in the countries around the Pacific Ocean and in the Americas generally. Specimens from New Guinea were formerly identified with the Eurasian *S. Tabernaemontani* Gmel. by Kükenthal in Engl. Bot. Jahrb. 59: 51. 1924, and by Ohwi in Bot. Mag. Tokyo 56: 203. 1942. I have accepted Beetle's arrangement of this group of species in Amer. Jour. Bot. 28: 691-700. 1941.

Scirpus grossus L. f. Suppl. 104. 1781; Valck. Suring. Nova Guin. Bot. 8: 705. 1912.

PAPUA: Western Division: Gaima, Lower Fly R. (east bank), *Brass 8311*, Nov. 1936, co-dominant with no. 8312 (= *Cyperus malaccensis* Lam.) in extensive sedge communities on open sandy foreshores (det. Uittien).

New for Papua. The species ranges from India to NE. Queensland, and in New Guinea was previously known only from Netherlands New Guinea.

Scirpus crassiusculus (Hook. f.) Benth. Fl. Austral. 7: 326. 1878; Kükenth. Bot. Jahrb. 69: 258. 1938.

Isolepis crassiuscula Hook. f. Fl. Tasm. 2: 86, t. 143. 1860.

NETHERLANDS NEW GUINEA: Lake Habbema, *Brass 9324*, Aug. 1938, alt. 3225 m., gregarious on sand bars in grassland stream; Mt. Wilhelmina, 4 km. NE. of top, *Brass & Meyer-Drees 9984*, Sept. 1938, alt. 3660 m., submerged green masses in shallows of a lake.

PAPUA: Central Division: Mt. Albert Edward, *Brass 4300*, May-July 1933, alt. 3810 m., submerged in large masses on shallows of an alpine lake.

New for both Netherlands New Guinea and Papua. Recorded by Kükenthal, l.c., for North-East New Guinea, but he credited the authorship of the combination under *Scirpus* to Hooker f., l.c. Bentham, l.c., also credited the combination to Hooker. The species is elsewhere known from SE. Australia (including Tasmania) and New Zealand.

The sheet seen of *Brass & Meyer-Drees 9984* has but one spikelet, too immature for dissection, but the facies of the plant is of this species.

Scirpus merrillii (Palla) Kükenth. ex Merr. Enum. Philipp. Fl. Pl. 1: 117. 1925; S. T. Blake, Proc. Roy. Soc. Queensl. 58: 38. 1947.

Schoenoplectus merrillii Palla in Kneucker, Cyperaceae (excl. Carices) et Juncaceae exsiccatae 8: nr. 223. 1911, in Allgem. Bot. Zeitschr. 17: Beil. 3. 1911.

NETHERLANDS NEW GUINEA: Lake Habbema, Brass 9238, Aug. 1938, alt. 3225 m., associated with mosses, etc., on open seepages.

PAPUA: Central Division: Mt. Albert Edward, Brass 4364, May-July 1933, alt. 3680 m., plentiful on wet banks of a small alpine stream; Murray Pass, Wharton Range, Brass 4725, June-Sept. 1933, alt. 2840 m., common, wet banks of grassland streams. Eastern Division: Mt. Dayman, W. Armit in 1894 (MEL).

New for New Guinea, though it is very likely this species which has been recorded as *S. inundatus* (R. Br.) Poir. by Kükenthal, Bot. Jahrb. 69: 258. 1938, from North-East New Guinea and by Ohwi, Bot. Mag. Tokyo 56: 203. 1942, from Netherlands New Guinea. It differs from the polymorphic *S. inundatus* by the constant development of a filiform branched rhizome, well-developed leaves often overtopping the culm, more or less emarginate glumes nearly as broad as long and scarcely if at all mucronate, and with the nut nearly as long as the glume; also it is almost invariably a much smaller, very slender, more or less mat-like plant with mostly only one, rarely two or three spikelets, and the involucral bract is commonly elongated. I have seen other specimens from the Philippine Islands including an isotype (*Merrill in Kneucker Cyperaceae et Juncaceae exsiccatae* 8, nr. 223), south-east Queensland, New South Wales, Victoria, Tasmania and New Zealand.

Scirpus clarkei Stapf, Trans. Linn. Soc. II, Bot. 4: 244. 1894.

Scirpus pulogensis Merr. Philipp. Jour. Sci. 5 (C): 333. 1910; syn. nov.

Scirpus pakapakensis Stapf, Jour. Linn. Soc. Bot. 42: 174. 1914; syn. nov.

Scirpus subcapitatus Thw. var. *triangularis* Kükenth. Bull. Jard. Bot. Buitenz. sér. III, 16: 301. 1940; syn. nov.

Scirpus subcapitatus Thw. forma *rigidus* Kükenth., l.c., syn. nov.

Scirpus clarkei Stapf var. *pakapakensis* (Stapf) Beetle, Amer. Jour. Bot. 33: 665. 1946; syn. nov.

PAPUA: Central Division: Mt. Albert Edward, Brass 4315, May-July 1933, alt. 3680 m., forest glades and grassland slopes, common, few plants fertile; Mt. Knutsford, W. MacGregor in 1889 (BRI, MEL); summit of the Owen Stanley Ranges, W. MacGregor in 1889 (MEL).

New for New Guinea; elsewhere known from the Philippine Islands, Borneo and Sumatra.

F. Mueller, Trans. Roy. Soc. Vict. n.s. 1 (2): 35. 1889, referred MacGregor's specimens to *S. caespitosus* L. (as *S. caespitosus*) with the remark: "Should nevertheless this plant, as a variety or perhaps even as a species, require separation from the genuine *S. caespitosus*, then the name *heleocharoides* would be an apt one." Some of the specimens are labelled in

Mueller's handwriting: *Scirpus caespitosus* Linné var. *heleocharoides*. This ternary combination has never been validly published, for the phrase quoted cannot be taken as constituting publication of any combination.

The specimens from New Guinea do indeed closely resemble specimens of *S. caespitosus* L., but the leaf-sheaths are fewer, tighter and more rigid, the hard culms are more or less trigonous and less furrowed, the two lowermost glumes are much shorter and more rigid than the others and only shortly pointed, and the nut is narrower. Occasionally also the inflorescence consists of two spikelets. They also resemble some from the Philippine Islands (ISOTYPE of *S. pulogensis*), Borneo (Mt. Kinabalu, the type-locality of *S. clarkei* and *S. pakapakensis*) and Sumatra (general locality of the types of *S. subcapitatus* var. *triangularis* and *S. subcapitatus* forma *rigidus*). *Scirpus clarkei* will probably prove to be conspecific with *S. subcapitatus* Thw. from Ceylon and southern India; of this I have seen only one sheet, an isotype, but it is in flower only.

Beetle, in the paper quoted above, recognised five taxa in a group which he described as *Scirpus* sect. *Paucispicatae* Beetle, l.c., 664. He distinguished *S. clarkei* from *S. subcapitatus* on differences in the number of spikelets and scabridity of the mucro to the leaf-sheaths and lowermost glumes. *Scirpus pakapakensis* was distinguished as a variety of *S. clarkei* by the spikelet not solitary and the stems more or less triangular. He also saw only a single sheet in flower (an isotype) of *S. subcapitatus*. The number of spikelets and shape of the culms are certainly variable, but on the material seen the character of scabridity seems constant. I have not seen material of the other species admitted by Beetle.

F. Mueller, l.c., remarked that "Another *Scirpus* is contained in the collections, as gathered on Mt. Knutsford and Mount Musgrave; it is an aged state of fructification, and may perhaps belong to the variety *fluvialis* of *S. maritimus*." These specimens are of *Mapania Moseleyi* C. B. Clarke.

Fimbristylis Vahl

No satisfactory account of this genus as a whole has ever been published. The latest account which has any claim to be considered as a general treatment of the genus is Boeckeler's uncritical descriptions of the forms represented in the Berlin Herbarium in *Linnaea* 37: 2-56. 1871, 38: 384-398. 1874. In *Kew Bull. Add. Ser. 8*: 107-109. 1908 is a list of species as accepted and arranged by C. B. Clarke, but one of the tragedies in botany is that his extensive manuscript on the family was never published.

The study of the New Guinea collections, the results of which appear on the following pages, was based chiefly on the revision of the Australian species which I commenced in 1932, but which is not yet completed, owing to the numerous difficulties involved, due partly to the need of critically comparing some Australian forms with others described from other parts of the world, of which types were not readily accessible. Little was previ-

ously known of the *Fimbristylis*-flora of southern New Guinea, to which Mr. Brass has added a remarkable number of Australian forms.

For convenience, I have arranged the species under the four sections proposed by Bentham, Fl. Austral. 7: 298-9. 1878, an arrangement which has been fairly generally followed. The type-species of the genus, *F. dichotoma* (L.) Vahl, was arranged under *Dichelostylis* Benth., l.c., 299, but Boeckeler, op. cit. 3. 1841, had previously proposed the name *Eufimbristylis* for the section containing this species.

Sect. *Heleocharoides* Benth.

Fimbristylis setacea Benth. Lond. Jour. Bot. 2: 239. 1843; Valck. Suring. Nova Guin. Bot. 8: 702. 1912.

Fimbristylis acuminata (Retz.) Vahl var. *minor* Miq. Fl. Ind. Bat. 3: 314. 1859.

Fimbristylis acuminata (Retz.) Vahl var. *setacea* (Benth.) Benth. Fl. Austral. 7: 301. 1878.

Fimbristylis acuminata (Retz.) Vahl var. *setacea* (Benth.) Kükenth. Bot. Jahrb. 59: 47. 1924, 69: 257. 1938.

Isolepis cochleata Steud. Synops. Cyper. 100. 1855.

PAPUA: Western Division: Lake Daviumbu, Middle Fly R., Brass 7531A, August 1936, savannahs, abundant on hard-pans and swamp margins (det. Kükenthal as *Fimbristylis acuminata* (Retz.) Vahl var. *setacea* Bth.); Daru Island, Brass 6245, March 1936, abundant in flattened tufts on damp soil in savannah-forests.

New for Papua. The species ranges from Tropical Asia to northern and north-eastern Australia. Kükenthal, 1924, l.c., made a new combination *F. acuminata* (Retz.) Vahl var. *setacea* (Benth.) Kükenth., evidently overlooking Bentham's much earlier combination. But if this form is treated as a variety of *F. acuminata*, then the legitimate trinomial would be *F. acuminata* var. *minor* Miq., l.c. The species is very close to *F. acuminata*, differing chiefly in being smaller in all its parts.

Fimbristylis nutans (Retz.) Vahl, Enum. 2: 285. 1806.

Scirpus nutans Retz. Observ. 4: 12. 1786.

PAPUA: Western Division: Lake Daviumbu, Middle Fly R., Brass 7843, Sept. 1936, common on wet grass plains; Wuroi, Oriomo R., Brass 5750, Jan.-March 1934, alt. 10-30 m., very plentiful on open savannah.

Not previously recorded for New Guinea, though the species is known to extend from northern and north-eastern Australia to Malaya and China.

Fimbristylis tetragona R. Br. Prodr. 226. 1810; Kükenth. Mitteil. Thüring. Bot. Ver. N. F. 50: 8. 1943.

Fimbristylis cylindrocarpa Kunth, Enum. 2: 222. 1837.

Fimbristylis arnotii Thw. Enum. Pl. Zeyl. 348. 1864.

Fimbristylis xyroides Arnott ex Thw., l.c., in syn., *nomen nudum*.

Fimbristylis abjiciens Steud. Synops. Cyper. 107. 1855.

Scirpus tetragonus (R. Br.) Poir. Encycl. Suppl. 5: 98. 1817.

Mischospora efoliata Boeck. Flora 43: 113. 1860.

PAPUA: Western Division: Lake Daviumbu, Middle Fly R., Brass 7844, Sept. 1936, tufted on wet grass plains, plant bluish (det. Svenson).

New for New Guinea; also in southern and eastern Asia and northern Australia.

Fimbristylis dictyocolea sp. nov. (Sect. *Heleocharoides* Benth.). FIG. 1.

Herba perennis, caespitosa, circiter 20–40 cm. alta, fere aphylla. Culmi stricti, erecti, setacei, pluristriati, obscure quinquangulares, glabri, laeves vel minute asperuli, basi haud incrassati. Folia basalia perpaucia, setacea, triquetra, lateraliter compressa, glabra, laevia, brevia vel culmum fere adaequantia; folia caulina basi culmi inserta, ad vaginas arctas ore oblique sectas antice late hyalinis tandem reticulatim fissas redacta. Inflorescentia unispiculata, quasi ebracteata. Spicula erecta, pallida, oblonga vel ellipsoidea, utrinque \pm acuta, haud angulata, 7–9 mm. longa, 3 mm. lata, multi- et densi-flora. Rhachilla exalata. Glumae undique spiraliter arcte imbricatae, oblongae, apice obtusa rotundatae, muticae, omnino glabrae, dorso late coriaceae uninerves nec carinatae, lateribus membranaceae cellulis parvis breviter oblongis, marginibus etiam apice hyalinae, 4–5 mm. longae, 1–3 imae vacuae crassiores. Stamina 3; antherae lineares, prominule apiculatae, circiter 2 mm. longae. Stylus tenuis, complanatus, basi dilatatus, marginibus minute ciliolatus, circiter 3–3.5 mm. longus; stigmata 3, brevia. Nux straminea, lucidula, obovoidea, late umbonulata, vix stipitata, trigona, leviter tricostulata, minute reticulata verrucosaque cellulis extimis minimis distinctis hexagonis, 1 mm. longa, 0.7 mm. lata.

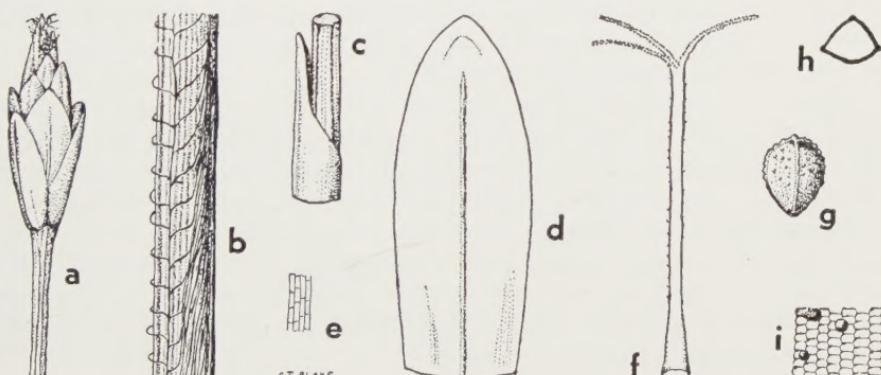


FIG. 1. *Fimbristylis dictyocolea* S. T. Blake: a. upper part of culm with spikelet, $\times 3$; b. middle part, and c. upper part of leaf-sheath, $\times 3$; d. glume, $\times 10$; e. portion of side of glume, $\times 40$; f. style, $\times 10$; g. nut, $\times 10$; h. transverse section of nut; i. surface of nut, $\times 40$. Figures from type.

PAPUA: Western Division: Tarara, Wassi Kussa R., *Brass* 8400, Dec. 1936, abundant on gray soil flat, savannah-forest; Mabaduan, *Brass* 6553 (TYPE), April 1936, common in shallow rain-pools in savannah-forests.

Brass 6553 had been determined by Svenson as *F. pauciflora* R. Br., while both it and *Brass* 8400, which is in flower only, were cited by Küenthal, Mitteil. Thüring. Bot. Ver. N. F. 50: 9. 1943 as *F. cardiocarpa* F. Muell. The species is certainly allied to *F. pauciflora* R. Br., and but for the larger size resembles it rather closely in the nut and style. It differs, however, in the coarser habit, the leaf-sheaths disintegrating into fine reticulate fibres, the larger and relatively much broader spikelet, and the rather larger, more oblong, more obtuse single-nerved muticous glumes. It is also allied to the Australian *F. simplex* S. T. Blake, but the latter has rather prominently swollen culm-bases, sheaths splitting into straight fibres, 3-5-nerved brownish glumes, entirely glabrous rather stout style and more shining nut cuneate at its base. On the other hand *F. cardiocarpa* F. Muell. is an entirely different plant, differing in almost every respect except for the solitary spikelet and three stigmas.

***Fimbristylis pauciflora* R. Br. Prodri. 225. 1810; Kükenth. Mitteil. Thüring. Bot. Ver. N. F. 50: 9. 1943.**

Fimbristylis filiformis (Nees) Kunth, Enum. 2: 221. 1837.

Scirpus pauciflorus (R. Br.) Poir. Encycl. Suppl. 98. 1817.

Trichelostylis filiformis Nees in Wight, Contrib. 102. 1834.

PAPUA: Western Division: Lake Daviumbu, Middle Fly R., *Brass* 7531, August 1936, savannahs, abundant on hard-pans and swamp margins; Gaima, Lower Fly R. (east bank), *Brass* 8357, Nov. 1936, covering patches of sour soil in savannah-forest (det. Uittien); Wuroi, Oriomo R., *Brass* 5817, Jan.-March 1934, alt. 10 m., plentiful, shaded ground on a clearing in savannah, flat spreading and rather fleshy.

Brass 7531 was recorded by Küenthal, l.c., as new for New Guinea; previously known from northern and north-eastern Australia, other parts of Malaysia, and southern and eastern Asia.

Brass 5817 represents what appears to be the usual state in which three stigmas are present. In *Brass* 7531 some flowers have two stigmas only, and flowers with two stigmas are the rule in *Brass* 8357. Nuts produced from flowers with three stigmas are always finely 3-ribbed and \pm trigonous, though at times distinctly compressed. Three-ribbed nuts have also been observed produced from flowers with two stigmas, though bi-convex two-ribbed nuts are more usual. Both trigynous and digynous flowers have been observed on a collection from Johore, *Ngadiman* in Singapore Field No. 36784.

Fimbristylis pumila Benth. Lond. Jour. Bot. 2: 239. 1843, from Amboina, was later referred by its author in Fl. Austral. 7: 303. 1878, and by C. B. Clarke in Hook. f. Fl. Brit. Ind. 6: 633. 1893, to *F. pauciflora*. It was described as having a glabrous style with two stigmas and one-nerved oblong glumes, features which do not well accord with *F. pauciflora*.

Of the latter I have examined twelve good sets of specimens ranging from south-east Queensland to the Malay Peninsula, and in all these I find the style minutely ciliate and the glumes three- to seven-nerved and as much ovate as oblong. Bentham may have overlooked the minute sparse ciliation of the style, while the lateral nerves are often close to the keel of the glume.

Fimbristylis pauciflora is rather easily recognised by its small, unusually narrow, relatively few-flowered spikelets.

As a general rule in *Fimbristylis*, the number of stigmas is very constant in each species. *Fimbristylis pauciflora* shares with *F. tetragona* R. Br. the peculiarity of having either two or three stigmas. In *F. cymosa* R. Br., three stigmas occur in the lower part of the spikelet, but in the upper flowers there are often only two.

***Fimbristylis recta* F. M. Bail.** 3rd Suppl. Syn. Queensl. Fl. 80. 1890;
S. T. Blake, Proc. Roy. Soc. Queensl. 58: 44. 1947.

Fimbristylis xyridis R. Br. var. *rigidula* Benth. Fl. Austral. 7: 307. 1878.

Fimbristylis stricticulmis Domin in Biblioth. Bot. 20 (85): 452. 1915.

PAPUA: Western Division: Tarara, Wassi Kussa R., Brass 8714, Jan. 1937, savannah-forests, common in grass on ridges.

A distinctive species known previously only from northern Australia and Hammond Island in Torres Strait. It was discussed in some detail by S. T. Blake, l.c.

Sect. **Eufimbristylis** Boeck.

***Fimbristylis ferruginea* (L.) Vahl**, Enum. 2: 291. 1806; K. Schum. Notizbl. Bot. Gart. Mus. Berlin 2: 98. 1898; in Schum. & Lauterb. Fl. Deutsch. Schutzgeb. Südsee 197. 1901; Valck. Suring. Nova Guin. Bot. 8: 702. 1912; Kükenth. Bot. Jahrb. 59: 48. 1924, 69: 258. 1938.

Fimbristylis brevifolia R. Br. Prodr. 228. 1810.

Scirpus ferrugineus L. Sp. Pl. 74. 1753.

Scirpus brevifolius (R. Br.) Poir. Encycl. Suppl. 5: 99. 1817.

PAPUA: Western Division: Gaima, Lower Fly R. (east bank), Brass 8308. Nov. 1936. common on open sandy foreshores; Gaima, Lower Fly R. (east bank). Brass 8313. Nov. 1936. common on sandy foreshores; Upper Wassi Kussa R. (left branch), Brass 8642, Jan. 1937, abundant in brackish swamp; Daru Island. Brass 6212. Feb. 1936. gregarious in limited pure stands, associated with *Zoysia pungens* on saline marshy ground; Daru Island, Brass 6286, March 1936, scattered in marginal shallows of large swamp. Central District: Kerema, Brass 1224, March 1926, on banks of tidal creeks; Arva R., Carr 11436, Feb. 1935, sea-level, marshy places near beach, about 18 in. tall (CANB; very young!).

Brass 1224 and *Carr 11436* are cited by Kükenthal, 1938, l.c.; *Brass 8313* was received as having been determined by Kükenthal as *F. ferruginea* Vahl var. *tristachya* (R. Br.) Domin. It represents a not uncommon state of the species with the inflorescence reduced to one or two spikelets, commonly seen on young or small plants. It seems pointless to

give such reduced states taxonomic status. I doubt very much whether it truly represents *F. tristachya* R. Br., and in any case, if this be regarded as a variety of *F. ferruginea*, the legitimate ternary combination would be *F. ferruginea* (L.) Vahl var. *foliata* Benth. Fl. Austral. 7: 312. 1878, the epithet *foliata* having priority in the required position. The other specimens were received as having been determined by Uittien. The species is widely spread in the warmer parts of the world.

***Fimbristylis marianna* Gaud. in Freyc. Voy. 413. 1826.**

Fimbristylis maxima K. Schum. in Hollr. Fl. Kaiser Wilhelmsl. 24. 1889, in Schum. & Lauterb. Fl. Deutsch. Schutzgeb. Südsee 196. 1901; Valck. Suring. Nova. Guin. Bot. 8: 702. 1912; *syn. nov.*

PAPUA: Western Division: Lake Daviumbu, Middle Fly R., Brass 7847, 7878, Sept. 1936, common on wet grass plains (both det. Kükenthal); Wuroi, Oriomo R., Brass 5734, Jan.-March 1934, alt. 10-30 m., common all through savannahs.

NORTH-EAST NEW GUINEA: Augusta R., Hollrung 836, in 1877 (MEL; duplicate TYPE of *F. maxima*).

New for Papua; elsewhere known from North-East New Guinea, Marianne Islands and Philippine Islands. I have relied on Kükenthal's determination of Brass 7847 and 7878 for my concept of the species and the consequent reduction of *F. maxima* to synonymy.

***Fimbristylis aestivalis* (Retz.) Vahl, Enum. 2: 288. 1806.**

Fimbristylis aestivalis (Retz.) Vahl f. *glabra* Kükenth. Bot. Jahrb. 59: 49. 1924; *syn. nov.*

Scirpus aestivalis Retz. Obs. 4: 12. 1786.

PAPUA: Western Division: Penzara, between Morehead and Wassi Kussa Rivers, Brass 8438, Dec. 1936, wet shaded banks of a permanent water-hole (det. Kükenthal).

Brass's plant, representing the usual pubescent state, forms the first record of the species for Papua. Kükenthal, l.c., records as f. *glabra* a glabrous form from North-East New Guinea. Elsewhere the species is known from Australia to southern and south-eastern Asia.

***Fimbristylis annua* (All.) R. & S. Syst. 2: 95. 1817.**

Scirpus annuus All. Fl. Pedem. 2: 227. 1785.

PAPUA: Western Division: Wuroi, Oriomo R., Brass 6069, Jan.-March 1934, alt. 30 m., uncommon tufted species on savannah; Daru Island, Brass 6248, March 1936, common on damp soil in savannah-forest (det. Kükenthal as *F. diphyllo* [Retz.] Vahl f. *tomentosa* [Vahl] Kükenth.); Daru Island, Brass 6369, March 1936, plentiful in drainage ditches in savannah-forest. Central Division: Baroka, Nakeo District, Brass 3732, April 1933, alt. 30 m., common, damp savannah flats, plant grayish.

For discussion, see under *F. dichotoma*.

Fimbristylis dichotoma (L.) Vahl, Enum. 2: 287. 1806.

Fimbristylis diphylla (Retz.) Vahl, Enum. 2: 289. 1806; K. Schum. in Warb. Bot. Jahrb. 13: 265. 1891, Notizbl. Bot. Gart. Mus. Berlin 1: 47. 1895. 2: 97. 1898, in Schum. & Lauterb. Fl. Deutsch. Schutzgeb. Südsee 196. 1901; Valck. Suring. Nova Guin. Bot. 8: 702. 1912; Ridl. Trans. Linn. Soc. II. Bot. 9: 242. 1916.

Fimbristylis polymorpha Boeck. Linnaea 37: 14. 1871, in Engl. Forschungsr. S. M. S. Gazelle 4 (1): 17. 1889.

Fimbristylis novae-brittanniae Boeck. Bot. Jahrb. 5: 93. 1884, in Engl. Forschungsr. S. M. S. Gazelle 4 (1): 11. 1889; K. Schum. Bot. Jahrb. 9: 195. 1888, Notizbl. Bot. Gart. Mus. Berlin 2: 97. 1898, in Schum. & Lauterb. Fl. Deutsch. Schutzgeb. Südsee 196. 1901; Valck. Suring. Nova Guin. Bot. 8: 703. 1912.

Fimbristylis annua (All.) R. & S. var. *diphylla* (Retz.) Kükenth. Bot. Jahrb. 59: 47. 1924, *nomen ex* C. E. C. Fischer, Fl. Pr. Madras 1658. 1931.

NETHERLANDS NEW GUINEA: Balim R., *Brass 11731*, Dec. 1938, alt. 1600 m., common on grassy deforested slopes (leaves conspicuously hairy!); Balim R., *Brass 11816*, Dec. 1938, alt. 1600 m., common on sandy, long-deforested slopes, erect tufts 60–80 cm. high (leaves hairy!); Bele R., 18 km. NE. of Lake Habbema, *Brass 11489*, Nov. 1938, alt. 2200 m., common on grassy, formerly cultivated slopes, small clumps 60–80 cm. high (leaves glabrous!).

PAPUA: Western Division: Lake Daviumbu, Middle Fly R., *Brass 7927*, Sept. 1936, savannah, abundant on seepage area (plant almost entirely glabrous!); det. Uittien as *F. annua* [All.] R. & S.); Lake Daviumbu, Middle Fly R., *Brass 7521*, August 1936, savannah hard-pans (almost entirely glabrous!); det. Uittien as *F. annua* [All.] R. & S.); Gaima, Lower Fly R. (east bank) *Brass 8265*, Nov. 1936, open savannah-forest, plentiful in firm-set soil, inflorescence dark brown (leaves slightly hairy!); det. Uittien as *F. annua* [All.] R. & S.); Gaima, Lower Fly R. (east bank), *Brass 8307*, Nov. 1936, plentiful on open sandy foreshores (almost glabrous!); det. Uittien as *F. annua* [All.] R. & S.). Central Division: Kanosia, *Carr 11034*, Jan. 1935, sea-level, open places under light shade (glabrous!); Huia, *Brass 524*, October 1925, coast sand hills (nearly glabrous!); Baroka, Nakeo District, *Brass 3729*, April 1933, alt. 30 m., common, damp savannah flats (nearly glabrous!); Mafulu, *Brass 5480*, Sept.–Nov. 1933, alt. 1250 m., common on roadside (leaves ± hairy!); Mafulu, *Brass 5328*, Sept.–Nov. 1933, alt. 1250 m., grassy seepages on roadside, uncommon, plant bluish green, inflorescence erect (leaves distinctly hairy!); Mafulu, C. T. White 600, July–August 1918, alt. ca. 1200 m. (leaves distinctly hairy!).

Fimbristylis annua (All.) R. & S., *F. diphylla* (Retz.) Vahl and allied forms have been a fertile source of difficulty since the time of Linnaeus. According to C. B. Clarke in Thistleton-Dyer, Fl. Trop. Afr. 8: 416. 1902, "some closely allied plants, esteemed mere forms of *F. diphylla* by Kunth and Boeckler, are here regarded as distinct; even thus narrowed down, our *F. diphylla* has 140 names. It should, moreover, be understood that *F. diphylla* is so close to the preceding *F. dichotoma* that different cyperologists sort the material, as between these two, differently." On the pre-

ceding page Clarke cites *Scirpus annuus* All. (which is *Fimbristylis annua* [All.] R. & S.) as a synonym.

According to C. E. C. Fischer, Kew Bull. 1935: 149-50. 1935, the type of *Scirpus diphylloides* Retz. and consequently of *Fimbristylis diphylloides* (Retz.) Vahl is identical with the type of *Scirpus dichotomus* L., so that the plant which has been called *F. diphylloides* (Retz.) Vahl must be called *F. dichotoma* (L.) Vahl. Another name thus has to be applied to the plant which has been passing under the name of *F. dichotoma* (L.) Vahl, and according to Fischer, l.c., p. 149, the legitimate combination is *Fimbristylis bisumbellata* (Forsk.) Bubani.*

To my mind, *F. annua* (All.) R. & S. is conspecific with *F. depauperata* R. Br., and I have suggested previously, Univ. Queensl. Papers Dept. Biol. 1(13): 3. 1940, that this is specifically distinct from *F. dichotoma* (*F. diphylloides*), differing in the constantly annual habit, the softer and softly hairy leaves and bracts, the more or less hairy culms and rays, the glumes often minutely ciliolate at the upper edge, the cells composing the glumes less distinctly oblong (more nearly square) in shape, and in the relatively shorter and broader style. *Fimbristylis dichotoma* has sometimes hairy leaf-blades and more rarely hairy culms, but the hairs are more rigid and the blades stiffer than in *F. annua*. In this restricted sense, *F. annua* seems to have been previously unknown from New Guinea.

Fimbristylis dichotoma, or allied forms, has been reported under other names from New Guinea, apart from those recorded in the synonymy above. Of some of these I am uncertain of the taxonomic status, and some seem to be invalid names.

***Fimbristylis dipsacea* (Rottb.) C. B. Clarke in Hook. f. Fl. Brit. Ind. 6: 635. 1895.**

Scirpus dipsaceus Rottb. Descr. et Ic. 56, t. 12, fig. 1. 1773; F. Muell. Pap. Pl. 2: 35. 1886.

Echinolytrum dipsaceum (Rottb.) Desv. Jour. Bot. 1: 21, t. 1. 1808.

Isolepis dipsacea (Rottb.) R. & S. Syst. 2: 119. 1811.

PAPUA: Western Division: Strickland R., Bäuerlen in 1885 (BRI, MEL).

This collection, the only one recorded for New Guinea, was recorded by Mueller, l.c., as *Scirpus dipsaceus*. The formal transfer of the species to *Fimbristylis* was made by C. B. Clarke, l.c., though this author there cited Benth. in Gen. Pl. 3: 1049. Bentham gave reasons why it should be placed under *Fimbristylis*, but did not make the transfer.

Sect. *Trichelostylis* (Lestib.) A. Gray

***Fimbristylis signatus* nom. nov.**

* From Fischer's data, it is doubtful if this combination was validly published by Bubani; I have not seen the publication.

Fimbristylis debilis F. Muell. *Fragm. Phyt. Austr.* 1: 198. 1859, non Steud.
Syn. *Cyper.* 109. 1855.

Iriha debilis (F. Muell.) O. Ktze. *Rev. Gen. Pl.* 2: 753. 1891.

PAPUA: Western Division: Daru Island, *Brass 6250*, March 1936, frequent on damp soil in savannah-forest.

New for New Guinea: previously known only from northern Australia.

Fimbristylis eragrostis (Nees & Meyen) Hance, *Jour. Linn. Soc. Lond.* 13: 132. 1873; Kükenth. *Mitteil. Thüring. Bot. Ver. N. F.* 50: 9. 1943.

Abildgaardia eragrostis Nees & Meyen in Wight, *Contrib.* 95. 1834.

PAPUA: Western Division: Tarara, Wassi Kussa R., *Brass 8405*, Dec. 1936, savannah-forest, common on sour gray soil; Wuroi, Oriomo R., *Brass 5706*, Jan.-March 1934, alt. 10-30 m., common on lower savannah ridges. Central Division: Astrolabe Range, *W. E. Armit* in 1894-5 (MEL). South-Eastern Division: Sud-est Island, *W. MacGregor* in 1889 (MEL).

Brass 8405 was cited by Kükenthal, l.c., as new for New Guinea. The species extends northwards to China and southwards to Queensland.

Fimbristylis globulosa (Retz.) Kunth, *Enum. 2*: 231. 1837; Kükenth. *Bot. Jahrb.* 59: 49. 1924, 69: 258. 1938; Ohwi, *Bot. Mag. Tokyo* 56: 202. 1942.

Scirpus globulosus Retz. *Obs. 6*: 19. 1791.

NETHERLANDS NEW GUINEA: Bernhard Camp, Idenburg R., *Brass 14087*, April 1939, alt. 50 m., on thick beds of floating grass (*Leersia*) in a lagoon, erect in large clumps about 1.2 m. high.

PAPUA: Western Division: Lake Daviumbu, Middle Fly R., *Brass 7604*, August 1936, occasional on floating islands of swamps and lagoons.

New for Papua. Previously known from Netherlands New Guinea (Ohwi, l.c.), North-East New Guinea, New Ireland, Micronesia, Philippine Islands, Malaya and India.

Fimbristylis insignis Thw. *Enum. Pl. Zeyl.* 349. 1864.

PAPUA: Western Division: Mai Kussa R., *W. MacGregor* in 1890 (MEL).

New for New Guinea. Originally described from Ceylon and since reported from China, Borneo and Queensland. MacGregor's specimen was written up by F. Mueller simply as "Fimbristylis."

Fimbristylis complanata (Retz.) Link, *Hort. Berol.* 1: 292. 1827; Valck. *Suring. Nova Guin. Bot.* 8: 703. 1912; Palla in Rechinger, *Denkschr. Math.-Naturw. Kais. Akad. Wiss. Wien* 89: 498. 1913.

Scirpus complanatus Retz. *Obs. 5*: 14. 1789.

Fimbristylis autumnalis (L.) R. & S. var. *complanata* (Retz.) Kükenth. Bot. Jahrb. 59: 50. 1924.

PAPUA: Central Division: Port Moresby, C. T. White 4, July-August 1918.

New for Papua, but known from most of the warmer parts of the Old World. It is probably this species which was recorded as *Fimbristylis autumnalis* (L.) R. & S. by Warburg, Engl. Bot. Jahrb. 18: 186. 1893 and by K. Schumann and Lauterbach, Fl. Deutsch. Schutzgeb. Südsee 196. 1901.

***Fimbristylis microcarya* F. Muell.** *Fragn. Phyt. Austr.* 1: 200. 1859.

Fimbristylis autumnalis (L.) R. & S. var. *microcarya* (F. Muell.) Kükenth. Bot. Jahrb. 69: 258. 1938.

PAPUA: Central Division: Port Moresby, Carr 11847, April 1935, open savannah land by the sea (CANB).

This collection was cited by Kükenthal, l.c., as *F. autumnalis* (L.) R. & S. var. *microcarya* (F. Muell.) Kükenth., comb. nov. It is the only specimen I have seen from outside Australia, though according to C. B. Clarke in Hook. f. Fl. Brit. Ind. 6: 646. 1893 (where it is treated as a variety of *F. complanata* [Retz.] Link) the species extends to India. My reasons for regarding *F. microcarya*, *F. complanata*, and *F. autumnalis* as distinct species are given in Proc. Roy. Soc. Queensl. 48: 93. 1937.

***Fimbristylis salbundia* Kunth**, *Enum.* 2: 230. 1837.

PAPUA: Central Division: Urunu, Vanapa Valley, Brass 4805, July-August 1933, alt. 1900 m., common species in small swamps on grass country.

New for New Guinea; known previously from Assam and Burma. C. B. Clarke in Hook. f. Fl. Brit. Ind. 6: 647. 1893 and ex Domin, Biblioth. Bot. 85: 463. 1915, recorded it from Australia. Domin quoted a collection from the Victoria R., *F. Mueller*, but the specimens belong to *F. trachycarya* F. Muell., a species discussed by me in Proc. Roy. Soc. Queensl. 48: 92. 1937. Brass's specimen agrees with pieces of *Wallich* 3526 ex herb. Berlin and ex herb. Kew, cited in the original description and by C. B. Clarke, l.c.

***Fimbristylis miliacea* (L.) Vahl**, *Enum.* 2: 287. 1806, quoad basonym.

Scirpus miliaceus L. *Syst. Veg.* 10: 868. 1759.

Isolepis miliacea (L.) Presl. *Rel. Haenk.* 1: 188. 1830.

Trichelostylis miliacea (L.) Nees in Wight, *Contrib.* 103. 1834, quoad basonym.

Iriha miliacea (L.) O. Ktze. *Rev. Gen. Pl.* 2: 752. 1891.

Scirpus bengalensis Pers. *Syn.* 1: 68. 1805.

Fimbristylis ? bengalensis (Pers.) R. & S. *Syst.* 2: 94. 1817.

Scirpus quinquangularis Vahl, *Enum.* 2: 279. 1806; *syn. nov.*

Trichelostylis quinquangularis (Vahl) Nees in Wight, *Contrib.* 104. 1834; *syn. nov.*

Fimbristylis quinquangularis (Vahl) Kunth, Enum. 2: 229. 1837; *syn. nov.*
Iriha quinquangularis (Vahl) O. Ktze. Rev. Gen. Pl. 2: 752. 1891; *syn. nov.*
Scirpus pentagonus Roxb. Fl. Ind. 1: 229. 1820; ed. Carey 1: 218 (1831);
syn. nov.

Isolepis ? pentagona R. & S. Syst. Mant. 2: 69. 1824; *syn. nov.*

Fimbristylis boeckeleri Steud. Syn. Cyp. 113. 1855; *syn. nov.*

PAPUA: Central Division: Baroka, *Brass* 3733, April 1933, alt. 30 m., common on damp savannah flats, plant pale green.

A widely spread species not previously recorded for New Guinea. The application of the name is explained under the following species.

Fimbristylis littoralis Gaud. in Freyc. Voy. Bot. 413. 1826.

Scirpus tetragonus Poir. Encycl. 6: 767. 1804, nec (R. Br.) Poir. Encycl. Suppl. 5: 98. 1817, nec *Fimbristylis tetragona* R. Br. 1810.

Scirpus tetragonus Roxb. Fl. Ind. 1: 232. 1820; ed. Carey 1: 228. 1832.

Isolepis ? tetragona R. & S. Syst. Mant. 2: 69. 1824.

Fimbristylis tetragona A. Dietr. Sp. Pl. 2: 152. 1833, non R. Br. 1810.

Fimbristylis flaccidula Zoll. Syst. Verz. Ind. Archip. 2: 61. 1854.

Fimbristylis flaccida Steud. Syn. Cyp. 113. 1855.

Fimbristylis quadrangularis A. Dietr. ex Steud. Syn. Cyp. 114. 1855.

NETHERLANDS NEW GUINEA: Bernhard Camp, Idenburg R., *Brass* 13780. April 1939. frequent on logs floating in lagoons and backwaters at 50 m. alt.

PAPUA: Western Division: Palmer R., 1 mi. above junction with Black R., *Brass* 6946. June 1936. abundant on silt-covered gravel banks; Strickland R., W. *Bäuerlen* 22. July 1885 (BRI, MEL); Strickland R., W. *Bäuerlen* 529, Nov. 1885, on river banks (MEL); Gaima, Lower Fly R. (east bank), *Brass* 8310. Nov. 1936. common on open sandy foreshores; Daru Island, *Brass* 6042, March 1934, very common on swampy savannahs. Central Division: Thu, Vaitata R., *Brass* 1016, Feb. 1926, in the sago swamps; Laloki R., C. T. White 173, July–August 1918.

This is the widely spread plant commonly called *Fimbristylis miliacea* (L.) Vahl; *Brass* 6946, 8310 had been so determined by Uittien, and the species has been recorded for New Guinea under this name by F. Muell. Pap. Pl. 2: 35. 1886; K. Schum. Notizbl. Bot. Gart. Mus. Berlin 2: 98. 1898, in Schum. & Lauterb. Fl. Deutsch. Schutzgeb. Südsee 197. 1901; Valck. Suring. Nova Guin. Bot. 8: 703. 1912; and Kükenth. Bot. Jahrb. 59: 50. 1924; also *F. miliacea* forma *tenerrima* Valck. Suring., l.c., Kükenth., l.c.

C. B. Clarke, Jour. Linn. Soc. Lond. 30: 312. 1894, stated that the type of *Scirpus miliaceus* L. is a plant of *Fimbristylis quinquangularis* (Vahl) Kunth. Through the kindness of Dr. E. D. Merrill and Dr. L. M. Perry, I have seen a small photograph of the Linnaean type, but unfortunately the photograph is not sufficiently sharp for critical comparison with specimens. Through the courtesy of the Director of the Royal Botanic Gardens, Kew, Mr. E. Nelmes kindly compared some Australian specimens with the Linnaean type. Mr. Nelmes reported as follows:

I have examined the "type" specimen of *Scirpus miliaceus* in the Linnaean herbarium and agree with C. B. Clarke that it represents the species generally known as *Fimbristylis quinquangularis* (Vahl) Kunth. It is a good match of Mr. S. T. Blake's specimen, no. 11319.

Linnaeus has written "miliaceus" on the sheet, and I think the specimen may be accepted as his type. There is, however, another Linnaean specimen, placed next after the type, which has some bearing on this matter, because it is the species which has always been known as *Scirpus miliaceus* L., agreeing well with Mr. Blake's nos. 7818, 8195, and 8784. C. B. Clarke does not mention this second sheet, probably because it bears no inscription by Linneaus. . . .

The combination *Fimbristylis miliacea* based on Linnaeus' name must be restricted to the species represented by Linnaeus' type, i.e., to the plant commonly called *F. quinquangularis*; no other course can be taken that would be in accord with the International Rules of Nomenclature. C. B. Clarke's suggestion, i.e., that Linnaeus would surely have esteemed the two as one species, does not warrant the deliberate continuance of the misapplication of the name. N. L. Burman, Fl. Ind. 22, t. 9, fig. 2. 1768, seems to have been the first to misapply Linnaeus' name, and since then the misapplication has been scarcely questioned.

Several names have been applied to one or other of the two species commonly known as *F. miliacea* and *F. quinquangularis*. Of these only *Scirpus miliaceus* L., *Scirpus bengalensis* Pers., *Scirpus quinquangularis* Vahl, *Scirpus pentagonus* Roxb., *Fimbristylis boeckeleri* Steud., *Fimbristylis flaccida* Steud., and *Fimbristylis flaccidula* Zoll. were based on specimens, and they are the basonyms of the remaining names. I have seen types of a portion thereof of *S. bengalensis* (L), *S. quinquangularis* (c), *F. littoralis* (P) and *F. flaccida* (P). *Fimbristylis flaccida* and *F. flaccidula* were probably based on the same collection, but I have not been able to verify this. *Scirpus tetragonus* Poir. and *S. tetragonus* Roxb. were described quite independently of each other; from the descriptions and specimens from the type-localities there seems no doubt as to the interpretations of these names or of *F. boeckeleri*. I am not so sure of *S. pentagonus*, though the description applies well enough to the leafless states of the species commonly called *Fimbristylis quinquangularis*. Blake 11319, matched with the type of *S. miliaceus*, also matches the type of *S. quinquangularis*.

Another name must be found for the species commonly called *Fimbristylis miliacea*. The earliest epithet in the required position is in the combination *Scirpus tetragonus* Poir. Encycl. 6: 767. 1804, but this is not available under *Fimbristylis* because of *F. tetragona* R. Br. and upon which Poiret's later homonym was based in 1817. The next is in *Fimbristylis littoralis* Gaud., and this appears to be the correct name for the species. *Scirpus bengalensis* Pers. has been generally referred to this species, but Persoon's description ("involucro tetraphyllo spiculis. . . . ovatis (minutis): squamis concavo-carinatis mucronatis") agrees better

with true *Fimbristylis miliacea*; a recent examination of the type (L) confirms this.

Two other names require mention. "Fimbristylis angularis Steud." Syn. Cyp. 116. 1855 has been referred to *F. miliacea* (*F. quinquangularis*) by some. Steudel's combination was based on *Isolepis angularis* Schrad. ex R. & S. Syst. Mant. 2: 69. 1824. which appears to have been based on *Fimbristylis angularis* Link. Enum. Hort. Berol. 1: 289. 1821, so that Steudel's transfer was quite unnecessary. Boeckeler's description (Linnaea 37: 30-31. 1871) of what appears to be Link's type refers to some other species, particularly as to the long bracts, relatively large spikelets and sometimes bifid styles. *Fimbristylis trachycarya* F. Muell. Fragm. 1: 199. 1859, sometimes referred to *F. littoralis*, belongs to an endemic Australian species which has been discussed elsewhere (S. T. Blake, Proc. Roy. Soc. Queensl. 48: 92. 1937).

Fimbristylis littoralis and *F. miliacea* do not differ greatly in spikelet structure, though the more or less globular, very obtuse, scarcely at all angular spikelets of the former with their muticous and more or less concave glumes are, with a little experience, readily enough distinguished from the ovoid, less obtuse, more distinctly angular spikelets of the latter with their rather prominently keeled, more or less distinctly apiculate glumes. The foliage of the two species is markedly dissimilar, but is sometimes poorly developed. The leaves of *F. littoralis* are vertically flattened, finely striate without prominent veins, with rather thin edges, and are usually borne as distichous, more or less flabellate tufts between the culms. The leaves of *F. miliacea* are of the usual *Fimbristylis* type, dorso-ventrally flattened with a prominent midrib and rib-like margins. The revised synonymy of the two species is given above.

Fimbristylis furva R. Br. Prodr. 228. 1810.

PAPUA: Western Division: Mai Kussa R., W. MacGregor in 1890 (MEL).

Previously known only from Queensland, including islands in Torres Strait.

Fimbristylis pycnocephala Hillebr. Fl. Haw. Isl. 473. 1888.

Fimbristylis cymosa R. Br. var. *capitato-umbellata* Hillebr. Fl. Haw. Isl. 473. 1888; *syn. nov.*

Fimbristylis cymosa R. Br. var. *subcapitata* C. B. Clarke ex Hemsl. Jour. Linn. Soc. Lond. 30: 197. 1894.

Fimbristylis cymosa R. Br. var. *pycnocephala* (Hillebr.) Kükenth. in Christopher, Bull. Bishop Mus. 128: 20. 1935.

SOLOMON ISLANDS: Ulawa, Brass 2990, October 1932, ocean foreshore, common.

New for the Solomon Islands; previously known from the Hawaiian Islands (!), Tonga (!), New Caledonia and Samoa.

In this species, the spikelets may all be aggregated in a single dense head or clustered on the rays of an umbel-like inflorescence; all intermediate states occur. Hawaiian plants with the looser inflorescences were referred by Hillebrand to *F. cymosa* R. Br. and *F. cymosa* var. *capitato-umbellata*, but all states of *F. pycnocephala* may be distinguished from the Australian *F. cymosa* as follows:

Spikelets \pm oblong; broad, hyaline margins of glumes loosely reticulate; nut somewhat shining, smooth or minutely striate only, the epidermal cells minute, square or nearly so, arranged in fairly regular vertical series but the transverse arrangement \pm irregular *F. pycnocephala*.

Spikelets ovoid; broad, hyaline margins of glumes not evidently reticulate, the cells composing them very small with inconspicuous margins; nut somewhat roughened, rather indistinctly striate vertically and horizontally, the minute epidermal cells transversely narrowly oblong, arranged regularly in both vertical and horizontal series *F. cymosa*.

Sect. *Abildgaardia* (Vahl) Benth.

Fimbristylis cinnamometorum (Vahl) Kunth, Enum. 2: 229. 1837;
Kükenth. Mitteil. Thüring. Bot. Ver. N. F. 50: 9. 1943.

Scirpus cinnamometorum Vahl, Enum. 2: 278. 1806.

Fimbristylis cyperoides R. Br. Prodr. 228. 1810.

PAPUA: Western Division: Tarara, Wassi Kussa R., Brass 8408, Dec. 1936, savannah-forest, abundant on wet flats; Lake Daviumbu, Middle Fly R., Brass 7876, Sept. 1936, occasional in small erect tufts on wet grass plains; Gaima, Lower Fly R. (east bank), Brass 8262, Nov. 1936, plentiful on hard soil in open savannah-forests.

These are the only collections known from New Guinea, though the species is known to range from NE. Australia to Ceylon and SE. Asia.

Fimbristylis cinnamometorum and *F. cyperoides* have sometimes been treated as distinct species on the grounds that the former (from Ceylon, Pegu and China) is an annual, while the latter (from Australia to the Philippine and Caroline Islands) has a prominent rhizome. But the type of *Scirpus cinnamometorum* (c) is from a perennial plant and is well matched by many Australian specimens; the degree of development of a rhizome depends on the age of the plant and varies greatly in herbarium material.

Fimbristylis stenochlaena Kükenth. Mitteil. Thüring. Bot. Ver. N. F. 50: 11. 1943.

PAPUA: Western Division: Lake Daviumbu, Middle Fly R., Brass 7840, Sept. 1936, very abundant on wet grass plains, leaves of young plants arranged spirally in a flat rosette (TYPE collection).

The plants seen by me appear to be somewhat larger than those seen by Kükenthal, 30–50 cm. high, with asperulous many-ribbed rather than smooth obsoletely pentagonal sulcate culms, with 9 or 10 (not 4–6)

-rayed inflorescences with rather longer and broader mature spikelets 9–11 mm. long and 2–3 mm. wide (described by Kükenthal as 8–9 mm. long and 1.5–2 mm. wide). I find the glumes acute and more or less cuspidulate rather than long acuminate, and the nuts (five examined) obovoid, not at all pyriform, 0.8 mm. long, 0.55 mm. wide.

Fimbristylis fusca (Nees) C. B. Clarke in Hook. f. Fl. Brit. Ind. 6: 649. 1893.

Abildgaardia fusca Nees in Wight, Contrib. Bot. Ind. 95. 1834.

NETHERLANDS NEW GUINEA: Balim R., Brass 11744, Dec. 1938, alt. 1600 m., common among the grass on long-deforested slopes.

New for New Guinea; previously known from India and the Philippine Islands to Java and the Moluccas. The plants are glabrous.

Clarke, l.c., cites "Benth. in Gen. Pl. iii. 1048" as the author of the combination, but Bentham here merely reduces the genus *Abildgaardia* to a section of *Fimbristylis*. In Index Kewensis, Suppl. 4: 92. 1913 the author of the combination is given as "Benth. ex C. B. Clarke in Hook. f. Fl. Brit. Ind. vi. 649 (1893)."

Fimbristylis fimbriostyloides (F. Muell.) Druce, Rep. Bot. Exch. Club Brit. Isles 1916: 623. 1917.

Abildgaardia fimbriostyloides F. Muell. Fragm. Phyt. Austr. 8: 273. 1874.

PAPUA: Central Division: Rona, Laloki R., Brass 3576, April 1933, alt. 450 m., common, wet places on open grassy hillsides.

New for New Guinea; previously known only from northern Queensland.

Fimbristylis intonsa sp. nova (Sect. *Abildgaardia*). FIG. 2.

Herba annua, usque ad 16 cm. alta. Culmi fasciculati, setacei, stricti, erecti, quinquangulares angulis angustis elevatis sursum scabris. Folia pauca, usque ad 5 cm. longa, culmi tertiam partem raro adaequantia, 1–2 mm. lata, caulina 1–2; vaginae striatae, antice hyalinae, summa prope orificem pubescens, ceterae glabrae; laminae lineares, sursum admodum angustatae, apice obtusae vel acutae, falcatae vel tortuosae, planae vel incurvae, coriaceae, haud carinatae, paucinerves, marginibus leviter in-crassatae sursum scabrae, supra prominule subtus indistincte cellulosoreticulatae, eae foliorum caulinorum saepe multo breviores angustioresque. Anthela simplex vel composita, 2–7-radiata, laxa. Bracteae 1–2 infimae subfoliaceae usque ad 12 mm. longae, vel omnes setaceae, saepe minimae; bracteolae minimae. Radii setacei, compressi, scabri, usque ad 2.5 cm. longi; radioli suberecti, usque ad 7 mm. longi. Spiculae oblongae, acutae, compressae, saepe tortae, 5–8 mm. longae, 1.5–1.8 mm. latae, multi- et densiflorae; rhachilla excavata alata. Glumae distichae vel sursum specie laxe spiraliter dispositae, brunneae vel ferrugineae, latissime ovatae,

obtusae, mucronatae, 1-nerves, carinatae carina curva sursum valida excurrente, fere omnino albo-pubescentes, marginibus vix hyalinis ciliatae, 1.7–1.8 mm. longae, cellulis minutissimis; 1–2 infimae vacuae minores. Stamina 3; antherae lineares, apiculatae, 0.5 mm. longae; filamenta lata. Stylus pro ratione robustus, triquetrus, basi latiuscule pyramidatus, omnino glaber, 1 mm. longus; stigmata 3, stylo breviora. Nux albida, obovoidea fere ellipsoidea, utrinque rotundata apice leviter umbonulata, minime stipitata, obtuse trigona angulis haud prominulis, lateribus convexulis, verrucosa, 0.7 mm. longa, 0.5 mm. lata, cellulis extimis hexagonis parvis indistinctis.

PAPUA: Western Division: Lake Daviumbu, Middle Fly R., Brass 7841, Sept. 1936, very common on wet grassy plains (TYPE).

This collection was labelled "Fimbristylis disticha Boeck. (det. Küenthal)." It is certainly allied to *F. disticha* Boeck., but to judge from the piece of the type of this species in herb. Brisbane ex herb. Berlin, it differs in the broader, more coarsely keeled, prominently mucronate and densely pubescent glumes and the broader, more ellipsoid nut not cuneate but rounded at the base, less distinctly ribbed at the angles and with hexagonal rather than oblong external cells. According to C. B. Clarke in Hook. f. Fl. Brit. Ind. 6: 651. 1893, the glumes of *F. disticha* are minutely ciliate at the margins, but I find them glabrous. Küenthal, Bot. Jahrb. 59: 50. 1924, and 69: 258. 1938, has recorded *F. disticha* from North-East New Guinea, but I have not seen these specimens.

The species of sect. *Abildgaardia* discussed may be distinguished as follows:

Leaves setaceous, at least half as long as culm, more or less distichous; basal sheaths \pm horny; glumes scabrous with reddish glands; nut (0.8–1 mm. long) with the external cells transversely oblong. *F. cinnamometorum*.

Leaves flat, at least 1 mm. wide, less than half and sometimes scarcely one quarter as long as culm, spirally arranged, often falcate; basal sheaths not horny, prominently nerved; glumes not (or in *F. fusca* very rarely) glandular, usually pubescent (except in *F. disticha*); nut (0.6–1 mm. long) with the external cells hexagonal, not or but slightly elongated transversely.

Glumes 3–5 mm. long, the upper ones somewhat spiral; style 3–4 mm. long, 3–6 times as long as the obovoid nut; perennial (?) always).



FIG. 2. *Fimbristylis intonsa* S. T. Blake: a. inflorescence, $\times 1$; b., c. spikelets, $\times 3$; d. glume, $\times 15$; e. flower, $\times 15$; f. nut, $\times 15$; g. transverse section of nut; h. surface of nut, $\times 40$. Figures from type.

Glumes about half as wide as long, 4–5 mm. long; style 4 mm. long; culms many-ribbed; leaves 1.5–4 mm. wide; spikelets 2–3 mm. wide. *F. stenochlaena*.

Glumes more than half as wide as long, 3–4 mm. long; style about 3 mm. long; culms 5-ribbed; leaves 2 mm. wide; spikelets 1.5–2 mm. wide. *F. fusca*.

Glumes up to 2.5 mm. long, regularly distichous, but the whole spikelet sometimes twisted; style 1–1.3 mm. long, less than twice as long as nut; annual plants.

Glumes glabrous, muticous or nearly so, acute, the keel slightly curved, 1.6–1.7 mm. long; nut narrowly obovate, cuneate to a very narrow base, about 0.6×0.35 mm. *F. disticha*.

Glumes puberulous or rarely glabrous, acute, mucronulate, the keel straight or nearly so, 2–2.5 mm. long; nut broadly obovate, somewhat attenuate above the broad truncate base, about 0.75×0.55 mm. *F. fimbristyloides*.

Glumes densely pubescent with ciliolate scarcely hyaline margins, very broad and very obtuse, rather coarsely mucronulate, the keel curved, 1.7–1.8 mm. long; nut obovate, rounded to the base, 0.7×0.5 mm. *F. intonsa*.

Scleria Bergius

There is no recent general account of the species of *Scleria* in the Malaysian-Australian region. A revision of the Australian species was commenced some years ago and has been intensified and expanded more recently to include the Malaysian species. The following account of the Brass collections is really a preliminary revision of all the species known from New Guinea. It would seem that a large number of names for alleged new species have been based on far too scanty material, and that very little attention has been paid to individual variation. Misapplications of names have been fairly frequent; it would appear that some early botanists did not see the types of the names proposed by their predecessors (which are frequently scrappy in any case), and their often faulty identifications were blindly accepted by later botanists, possibly for want of better evidence. I have been fortunate in seeing types or isotypes of a goodly proportion of the names mentioned in this paper; of others I have seen topotypes—specimens from the type-locality which agree with the original description. Although an extensive series of specimens from Australia, Malaysia and elsewhere has now been examined, study of further material, particularly from India, may demand modifications of some of the conclusions published in this paper.

A curious fact is that there appears to be no endemic species in New Guinea. Of the thirteen accepted species, all but one (*S. polycarpa*) occur elsewhere in Malaysia and all but two or three (*S. pergracilis*, *S. motleyi* and, perhaps, *S. tessellata*) occur in Australia, some of them extending further eastward.

Scleria pergracilis (Nees) Kunth, Enum. Pl. 2: 354. 1837.

Hypoporum pergracile Nees, Edinb. New Philipp. Jour. 17: 267. 1834.

NORTH-EAST NEW GUINEA: Kani Hills near Ongoruna (Unguruna) Village, *Lane-Poole* 635, Feb. 1924 (has as strong a lemon-verbena scent as to make a whole hill-top perfumed); Partep, *Commonwealth Nutritional Survey N. S. P.* 69, *N. S. P.* 92.

New for New Guinea; previously known from Tropical Africa, India and Ceylon.

Scleria lithosperma (L.) Sw. Prodr. Veg. Ind. Occid. 18. 1788; Boeck. in Engl. *Forschungsr. S. M. S. Gazelle* 4 (1): 18. 1889; K. Schum. & Lauterb. *Nachtr. Fl. Deutsch. Schutzgeb. Südsee* 60. 1905; Valck. Suring. *Nova Guin. Bot.* 8: 711. 1902; Kükenth. *Bot. Jahrb.* 59: 58. 1924; Ohwi, *Bot. Mag. Tokyo* 56: 212. 1942.

Scirpus lithospermus L. Sp. Pl. ed. 1: 51. 1753.

Schoenus lithospermus (L.) L. Sp. Pl. ed. 2: 65. 1762.

Scleria tenuis Retz. Obs. 4: 13. 1786.

Scleria capillaris R. Br. Prodr. 240. 1810.

Scleria wightiana Steud. Syn. Cyp. 176. 1855.

Hypoporum lithospermum Nees in Mart. *Fl. Brasil.* 2 (1): 172. 1842.

Hypoporum capillare (R. Br.) Nees, *Linnaea* 9: 303. 1834.

NORTH-EAST NEW GUINEA: New Britain, *Parkinson* in 1885 (MEL).

PAPUA: Western Division: Lower Fly R., east bank opposite Sturt Island, *Brass* 8059, Oct. 1936, rain-forest, tufts 60–80 cm. high, forming a scant ground cover on dry ridges; Daru Island, *Brass* 6259, March 1936, common along edge of rain-forest. Eastern Division: Lower Mori R., *Brass* 1634, June 1926, on rain-forest floor.

Cosmotropical. Further synonyms are listed by Core, *Brittonia* 2: 27–8. 1936. *Brass* 6259, 8059 had been determined by Kükenthal.

Scleria roxburghii (C. B. Clarke) Domin, *Biblioth. Bot.* 85: 487. 1915.

Scleria lithosperma (L.) Sw. var. β Thw. *Enum. Pl. Zeyl.* 354. 1864.

Scleria lithosperma (L.) Sw. var. *roxburghii* C. B. Clarke in Hook. f. *Fl. Brit. Ind.* 6: 686. 1894.

Scleria lithosperma (L.) Sw. var. *linearis* Benth. *Fl. Austral.* 7: 430. 1878.

Scleria roxburghii (C. B. Clarke) Domin var. *australiensis* Domin, *Biblioth. Bot.* 85: 487. 1915; *syn. nov.*

Hypoporum roxburghii Nees ex C. B. Clarke in Hook. f. *Fl. Brit. Ind.* 6: 686. 1894, in *syn.*

Hypoporum roxburghiana Nees ex Boeck. *Linnaea* 38: 452. 1874, in *syn.*

PAPUA: Western Division: Tarara, Wassi Kussa R., *Brass* 8504, Dec. 1936, rain-forest, dense tufted ground cover 50–60 cm. high, in partial shade. Central Division: Baroka, Nakeo district, *Brass* 3774, April 1933, alt. 30 m., common in brushy rain-forest and on garden clearings; Port Moresby to Kalo, *MacGregor* in 1889 (MEL).

New for New Guinea. Known elsewhere from Queensland, Philippine Islands, India and Ceylon.

Scleria motleyi C. B. Clarke, Philipp. Jour. Sci. 2 (C): 104. 1907;
Ohwi, Bot. Mag. Tokyo 56: 213. 1942.

Scleria motleyi C. B. Clarke var. *densi-spicata* C. B. Clarke, Philipp. Jour. Sci. 2 (C): 104. 1907; syn. nov.

Scleria trigonocarpa Ridl. Jour. Str. Branch Roy. As. Soc. 46: 228. 1906,
nomen. Mater. Fl. Malay. Pen. (Monocot.) 3: 110. 1907; non Steud. 1855.

Scleria trigona Merr. Philipp. Jour. Sci. 8 (C): 363. 1913.

Scleria gonocarpa Ridl. Fl. Malay Pen. 5: 177. 1925; syn. nov.

Scleria sorsogonensis Elmer ex Merr. Enum. Philipp. Fl. Pl. 1: 134. 1922, in
obs., pro syn.; Elmer, Leafl. Philipp. Bot. 10: 3541. 1938, descr. anglice.

Scleria subrostrata Elmer, Leafl. Philipp. Bot. 10: 3542. 1938, in obs., pro
syn.

NETHERLANDS NEW GUINEA: Hollandia and vicinity, *Brass* 8870,
June-July 1938, alt. 100 m., rain-forest, tufted floor plant on sharp ridge
crests.

Previously recorded by Ohwi, l.c., for Netherlands New Guinea; elsewhere known from Malaya, Borneo and Philippine Islands.

Scleria tessellata Willd. Sp. Pl. 4: 315. 1805; K. Schum. in Warb. Bot. Jahrb. 13: 267. 1891; Valck. Suring. Nova Guin. Bot. 8: 712. 1912.

Scleria parvula Steud. Syn. Cyp. 174. 1855.

Scleria uliginosa Hochst. ex Boeck. Linnaea 38: 471. 1874.

PAPUA: Western Division: Lake Daviumbu, Middle Fly R., *Brass* 7527, August 1936, sporadic on savannahs; Lake Daviumbu, Middle Fly R., *Brass* 7875, Sept. 1936, sporadic on wet grass plains, erect in small tufts; Lake Daviumbu, Middle Fly R., *Brass* 7963, Sept. 1936, rain-forest, common in semi-shade on shores of lake.

New for Papua; known to extend in an apparently sporadic manner north and west to India and Ceylon. Some of the records of this species from Mayalsia belong to the closely allied *S. biflora* Roxb. The Australian plants referred to it by Bentham, Fl. Austral. 7: 430. 1878 belong to other species.

Scleria novae-hollandiae Boeck. Flora 58: 120. 1875.

Scleria merrillii Palla, Allgem. Bot. Zeitschr. 17: Beil. 8. 1911; syn. nov.

PAPUA: Western Division: Wuroi, Oriomo R., *Brass* 6012, Feb.-March 1934, alt. 50 m., on a savannah ridge; Daru Island, *Brass* 6427, April 1936, gregarious on wet soil in savannah forest.

New for New Guinea; previously known from northern and north-eastern Australia and the Philippine Islands.

This species was referred by Bentham, Fl. Austral. 7: 428. 1878 to *S. laxa* R. Br., and in this he was followed by later authors. I have discussed these species as to their occurrence in Australia in Proc. Roy. Soc.

Queensl. 58: 48-9. 1947 and 60: 52-3. 1949. I have now seen the type and an isotype of *S. novae-hollandiae*, a photograph and a fragment of the type of *S. laxa* and isotypes of *S. merrillii*. The species is well distinguished from other small annual species by the dull white, nearly smooth surface of the more or less oblong nut and the small thin tightly appressed disc with broadly rounded lobes and shallow sinuses. The chalky appearance of most nuts is very distinctive. Kükenthal determined *Brass* 6427 as *S. tessellata*, which has an ellipsoid, shining, prominently tessellated nut and a larger, thicker, more deeply divided disc with rather acute lobes and sinuses. To judge from his remarks on the disc, the specimen upon which Kükenthal based his record for New Guinea of *S. brownii* Kunth, Bot. Jahrb. 70: 464. 1940 may also belong here.

***Scleria rugosa* R. Br. Prodr. 240. 1810.**

Scleria lateriflora Boeck. Linnaea 38: 455. 1874; **syn. nov.**

Scleria pubigera Makino, Bot. Mag. Tokyo 27: 55. 1913; **syn. nov.**

PAPUA: Western Division: Lake Daviumbu, Middle Fly R., *Brass* 7532 A, August 1936, savannahs, gregarious in flat tufts on hard-pans and swampy margins; Wuroi, Oriomo R., *Brass* 5868, Jan.-March 1934, alt. 30 m., rare, gray soil on low savannah ridge; Wuroi, Oriomo R., *Brass* 6013, Feb.-March 1934, alt. 30 m., damp slopes of a savannah ridge, uncommon.

New for New Guinea; previously known from northern and north-eastern Australia and New Caledonia northwards and westwards to Ceylon and Japan. Specimens from Ceylon (*S. lateriflora* Boeck.) were referred to *S. zeylanica* Poir. by Thwaites and others, but Poiret's original description refers to a large plant which, from the examination of an excellent piece of the type loaned from herb. Paris, proves to belong to the species previously described by Retz as *Scleria levis* and later described by Nees as *Scleria hebecarpa*. Apparently little attention has been paid to the extensive description in French following the brief Latin diagnosis. The references to *S. zeylanica* in Malaysian and New Caledonian literature really belong to *S. rugosa*. I have seen excellent isotypes of *S. rugosa* and *S. lateriflora*, but the interpretation of *S. pubigera* Makino is based chiefly on specimens so labelled from Taiwan in herb. Melbourne. *Brass* 7532 A was determined by Kükenthal as *Scleria tessellata* Willd. var. *debilis* Benth.; the latter is a common Queensland plant differing from *S. rugosa* in habit and the shape of the nut and disc.

***Scleria levis* Retz. Obs. 4: 13. 1786.**

Scleria zeylanica Poir. Encycl. Meth. 7: 3. 1806; **syn. nov.**

Scleria hebecarpa Nees in Wight, Contrib. Bot. Ind. 117. 1834; Valck. Suring. Nova Guin. Bot. 8: 712. 1912; Palla in Rechinger, Denkschr. Math.-Naturw. Kais. Akad. Wiss. Wien 89: 500. 1913; Kükenth. Bot. Jahrb. 59: 58. 1924; Ohwi, Bot. Mag. Tokyo 56: 212. 1942; **syn. nov.**

Scleria hebecarpa Nees var. *pubescens* (Steud.) C. B. Clarke in Hook f. Fl. Brit. Ind. 6: 689. 1894; **syn. nov.**

Scleria hebecarpa Nees forma *pilosa* Valck. Suring. Nova Guin. Bot. 8: 712. 1912; *syn. nov.*

Scleria neesiana Hook. & Arn. Bot. Beechey Voy. 229. 1841; *syn. nov.*

Scleria pubescens Steud. Syn. Cyp. 168. 1855; *syn. nov.*

Scleria japonica Steud. Syn. Cyp. 169. 1855; *syn. nov.*

Scleria vestita Boeck. Linnaea 38: 482. 1874; *syn. nov.*

Scleria dietrichiae Boeck. Flora 58: 121. 1875; *syn. nov.*

Scleria wichurai Boeck. Bot. Jahrb. 5: 510. 1884; *syn. nov.*

PAPUA: Western Division: Lake Daviumbu, Middle Fly R., *Brass* 7877, Sept. 1936, occasional on wet grass plains (clumps 80 cm. high); Lake Daviumbu, Middle Fly R., *Brass* 7691, Sept. 1936, savannahs, common on swamp margins; Gaima, Lower Fly R. (east bank), *Brass* 8264, Nov. 1936, open savannah-forest, plentiful on hard soils; Tarara, Wassi Kussa River, *Brass* 8715, Jan. 1937, common grass associate, savannah-forest ridges; Dagwa, Oriomo R., *Brass* 5996, Feb.-March 1934, alt. 40 m., amongst grasses on a savannah ridge.

This species has not previously been recorded for Papua, though it is widely spread from Queensland and New Caledonia to India and Japan. It is the species commonly known as *Scleria hebecarpa* Nees, but examination of the type of *Scleria levis* Retz. (LD) and of a piece of the type of *Scleria zeylanica* Poir. (P) has shown that these three names are synonymous. For some inexplicable reason, Poiret's name has been almost invariably associated with *S. lateriflora* Boeck. (which is *S. rugosa* R. Br.) in spite of the fact that Poiret's description refers to a much larger and otherwise different plant (see also under *S. rugosa*). The name *Scleria levis* (the epithet of which is often spelled *laevis*) has been commonly applied to specimens of *S. terrestis* (L.) Fassett on which the fruits are somewhat depressed due to imperfect development.

Brass 8264 had been determined as *Scleria hebecarpa* Nees by Kükenthal. *Brass* 7691, 8715 represent the more or less hairy form described as *S. hebecarpa* Nees var. *pubescens* (Steud.) C. B. Clarke (and were determined as such by Kükenthal), *S. pubescens* Steud. and *S. vestita* Boeck.

Scleria ciliaris Nees in Wight, Contrib. Bot. Ind. 117. 1834.

Scleria chinensis Kunth, Enum. Pl. 2: 357. 1837.

Scleria bancana Miq. Fl. Ind. Bat. Suppl. 602. 1860; Valck. Suring. Nova Guin. Bot. 8: 712. 1912; Kanehira, Jour. Dept. Agr. Kyushu Univ. 4: 282. 1935; Kükenth. Bot. Jahrb. 69: 261. 1938; Ohwi, Bot. Mag. Tokyo 56: 212. 1942; *syn. nov.*

Scleria malaccensis Boeck. Linnaea 38: 507. 1874; K. Schum. in Warb. Bot. Jahrb. 13: 266. 1891; *syn. nov.*

PAPUA: Western Division: Lake Daviumbu, Middle Fly R., *Brass* 7670, Sept. 1936, rain-forest, occasional clumps 1.2-1.5 m. high, along margin of lake (det. Uittien as *S. hebecarpa* Nees); Gaima, Lower Fly R. (east bank), *Brass* 8252, Nov. 1936, common grass associate in savannah forests (det. Uittien as *S. hebecarpa* Nees); Wuroi, Oriomo R., *Brass* 5808, Jan.-March 1934, alt. 10 m., amongst tall grass on edge of rain-forest. Gulf Division: Kerema, *Brass* 1207, March 1926, open grassland near coast, in clumps 1 m.

high. Central Division: On range between Sogere and Javararie, *White* 317, July-Aug. 1918; Astrolabe Range, *White* 218, July-August 1918, in grass-land; Astrolabe Range, *Armit* (MEL). Eastern Division: Cloudy Mts., *Chalmers* (MEL).

SOLOMON ISLANDS: Mariga Island: N'Gela, *Brass* 3486, Jan. 1933, small sedge on grasslands.

New for Papua and the Solomon Islands; extends from northern Queensland northwards and westwards to Ceylon, India and China.

One state of this species has been generally called *Scleria chinensis* since the time of Kunth. Kunth proposed this name to replace *Scleria ciliaris* Nees "because of the earlier name of Michaux." But the name for the American species proposed by Michaux is *Scleria ciliata*. The suffixes *-tus* (*-ta*, *-tum* = provided with) and *-ris* (*-re* = of or belonging to) have quite distinct meanings, so that the two epithets *ciliata* and *ciliaris* (and consequently the names of which they form part) must be treated as distinct (International Code of Botanical Nomenclature, Art. 82, and Rec. 821); they are not orthographic variants. Kunth's action was therefore unjustified and merely created a superfluous name. The name proposed by Nees is the correct one.

Scleria malaccensis is the same form as *S. bancana* and has usually been distinguished on the grounds that the leaves of *S. ciliaris* (*S. chinensis*) are scattered and have more or less distinctly winged sheaths while *S. bancana* has the middle leaves approximated in pairs with usually un-winged sheaths, even though *S. bancana* was originally described as having winged sheaths. The specimens cited above show a continuous series between the two extremes.

I have not been able to identify *Scleria chinensis* Kunth var. *biauriculata* C. B. Clarke in Hook. f. Fl. Brit. Ind. 6: 690. 1894. The description could refer to members of the series just mentioned; the synonym cited, *S. exaltata* Boeck., belongs to *S. terrestris*; one of the two collections cited is also cited as belonging to the typical form of *S. chinensis* and the other may or may not be Boeckeler's type.

Scleria macrophylla Presl has been referred to *S. chinensis* by some authors, but this name refers to an American species (Core, Brittonia 2: 37-8. 1936).

Scleria terrestris (L.). Fassett, Rhodora 26: 159. 1924.

Zizania terrestris L. Sp. Pl. ed. 1: 991. 1753.

Diaphora cochinchinensis Lour. Fl. Cochinch. 578. 1790.

Olyra orientalis Lour. Fl. Cochinch. 552. 1790.

Scleria elata Thw. Enum. Pl. Zeyl. 353. 1864; K. Schum. Notizbl. Bot. Gart. Mus. Berlin 2: 98. 1898; Lam, Nat. Tijds. Nederl. 88: 194, 203, 207. 1928.

Scleria melanostoma Nees ex Boeck. Linnaea 38: 514. 1874.

Scleria exaltata Boeck. Bot. Jahrb. 5: 511. 1884; syn. nov.

Scleria hasskarliana Boeck. Bot. Jahrb. 5: 511. 1884; syn. nov.

Scleria haematochachys Boeck. Bot. Jahrb. 5: 512. 1884; syn. nov.

Scleria doederleiniana Boeck. Bot. Jahrb. 5: 512. 1884; syn. nov.

Scleria ploemii Boeck. Bot. Jahrb. 5: 513. 1884; **syn. nov.**

Scleria luzonensis Palla, Allg. Bot. Zeitschr. 13: 49. 1907; **syn. nov.**

Scleria cochinchinensis (Lour.) Druce, Rept. Bot. Exch. Club Brit. Isles 4: 646. 1917.

Scleria chinensis Kunth var. *luzonensis* (Palla) Uitt. Rec. Trav. Bot. Néerland. 32: 201. 1935 et Meded. Bot. Mus. Herb. Rijksuniv. Utrecht 17: 201. 1935; **syn. nov.**

Scleria chinensis Kunth var. *luzonensis* (Palla) Uitt. forma *pilosa* Uitt. ll.cc.; **syn. nov.**

NETHERLANDS NEW GUINEA: 4 km. SW. of Bernhard Camp, Idenburgh R., Brass 13480. March 1939, alt. 850 m., one clump on an open landslip.

NORTH-EAST NEW GUINEA: Morobe District: Belung R. to Sarawaket. J. & M. S. Clemens 4875, Jan. 1937.

PAPUA: Central Division: Port Moresby, *Lawes* in 1884 (MEL); Sogere, *White 308*, July-Aug. 1918; Urunu, Vanapa Valley, Brass 4779, July-Aug. 1933, alt. 1900 m., in clumps amongst tall weed grass on old garden land, common.

New for Papua; extends from Queensland to India and southern China.

This is the species commonly known as *Scleria elata* Thw. The name *Scleria terrestris* is based on *Zizania terrestris* L., which is based on *Katutsjolam* Rheede, Hort. Mal. 12: 113. t. 60. 1703, and this evidently refers to a *Scleria*; C. B. Clarke in Hook. f. Fl. Brit. Ind. 6: 685-694. 1894 recorded only *S. elata* Thw. and *S. hebecarpa* Nees from the region covered by Rheede, and Rheede's figure could only refer to *S. elata*. *Scleria cochinchinensis* is based on *Diaphora cochinchinensis* Lour., the type of which was seen by Merrill (see Trans. Am. Phil. Soc. n.s. 24: 89. 1935). *Olyra orientalis* Lour. is referred here on Merrill's suggestion, l.c., 90. I have seen syntypes of *Scleria elata* (MEL), *S. hasskarliana* (MEL), *S. luzonensis* (BRI, NSW, L) and possibly of *S. ploemii* (L). *Thwaites 3031*, cited by Boeckeler as the type of *S. exaltata*, is represented at Melbourne, but the specimen differs considerably from Boeckeler's description in being much smaller and having differently shaped disc-lobes; it belongs to *S. levis* Retz. (*S. hebecarpa* Nees).

Scleria scrobiculata Nees & Meyen in Wight, Contrib. Bot. Ind. 117.

1834; K. Schum. & Lauterb. Fl. Deutsch. Schutzgeb. Südsee 198.

1901 (at most only partly); Valck. Suring. Nova Guin. Bot. 8: 712.

1912 (at most only partly); Kükenh. Bot. Jahrb. 59: 58. 1924,

partly; ? Kanehira, Jour. Dept. Agr. Kyushu Univ. 4: 282. 1935;

(?) Ohwi, Bot. Mag. Tokyo 56: 212. 1942.

Scleria timorensis Nees, Linnaea 9: 303. 1834.

Scleria purpureovaginata Boeck. Bot. Jahrb. 5: 513. 1884; K. Schum. in Warb. Bot. Jahrb. 13: 266. 1891; Valck. Suring. Nova Guin. Bot. 8: 713. 1912; **syn. nov.**

Scleria keyensis K. Schum. in Warb. Bot. Jahrb. 13: 267. 1891; Valck. Suring. Nova Guin. Bot. 8: 713. 1912.

Scleria suffulta C. B. Clarke, Kew Bull. Add. Ser. 8: 58. 1908; **syn. nov.**

PAPUA: Western Division: New Guinea, near Dutch boundary, *MacGregor* in 1890 (MEL); Fly R., *D'Albertis* (MEL); Lake Daviumbu, Middle Fly R., *Brass* 7715, Sept. 1936, mixed with grass fringing shore of savannahs, clumps 2-2.5 m. high (det. Kükenthal); Daru Island, *Brass* 6244, March 1936, common with grasses on damp soil of savannah forests (det. Kükenthal as *Scleria chinensis* Kunth). Central Division: Port Moresby, *Goldie* (MEL); towards Owen Stanley Range, *Goldie* in 1878 (MEL); Astrolabe Range, *Armit* in 1883, scrubs (MEL).

New for Papua, and perhaps for New Guinea. The species is widely spread in Malaysia, extending into Queensland and apparently to China. At least some of the records of this species for New Guinea belong properly to *Scleria polycarpa* (see under this species), but I have not seen many of the specimens on which the records are based.

***Scleria polycarpa* Boeck. *Linnaea* 38: 508. 1874.**

Scleria margaritifera Willd. Sp. Pl. 4: 312. 1805; Rendle in Gibbs, *Phyt. Fl. Arfak Mts.* 200. 1917; non Gaertn. 1788; **syn. nov.**

Scleria graeffeana Boeck. *Flora* 58: 121. 1875; K. Schum. in Warb. Bot. Jahrb. 13: 266. 1891; Valck. *Suring. Nova Guin. Bot.* 8: 712. 1912; Palla in Rechinger, *Denkschr. Math.-Naturw. Kais. Akad. Wien* 89: 500. 1913; **syn. nov.**

Scleria ternifolia Domin, *Biblioth. Bot.* 85: 490. 1915; **syn. nov.**

NETHERLANDS NEW GUINEA: Bernhard Camp, Idenburg R., *Brass* 13937, April 1939, alt. 50 m., abundant in sago and other permanently swampy forest of river plain, 2-3 m. high.

NORTH-EAST NEW GUINEA: New Ireland: W. coast, *Bradtko* 125, May 1917, 0 m. (NSW). Duke of York Island, *Bradtko* 185, May 1917, secondary bush, grassfields (NSW). Morobe District: Augustusfluss (= Sepik R.) *Hollrung* 815 (MEL, L); Huon Gulf, *Lauterbach* 1185 (MEL).

PAPUA: Western Division: New Guinea, near Dutch boundary, *MacGregor* in 1890 (MEL); Fly R., *Bäuerlen* 514, Nov. 1885, on red clay banks; Lake Daviumbu, Middle Fly R., *Brass* 7590, Aug. 1938, forming dense thickets 2.5-3 m. high, in edge of forest along lake shores (det. Kükenthal as *S. scrobiculata* Nees); Lake Daviumbu, Middle Fly R., *Brass* 7663, Sept. 1936, savannahs, scattered clumps 1.5 m. high on swamp margins (det. Kükenthal as *Scleria chinensis* Kunth); Lower Fly R., east bank opposite Sturt Island, *Brass* 8115, Oct. 1936, tufted in semi-shade on edge of sago swamps (det. Kükenthal as *S. scrobiculata* Nees). Gulf Division: Ghu, Vaitata R., *Brass* 938, Feb. 1926, rain-forest borders, small clumps 2-3 ft. high. Central Division: Boku, *Schlenker* 9, July 1909; Deva Deva, *White* 588, alt. about 1200 m., July-August 1918 (large sedge about 6 ft. high); Kubuna, *Brass* 5563, Nov. 1933, alt. 100 m., common amongst ferny ground cover in rain-forest; Astrolabe Range, *White* 359; Sogere, *White* 370, July-August 1918; Bisiatabu, *Brass* 584, Nov. 1925, alt. 1500 ft., banks of streams; Owen Stanley Range, between Mts. Brown and Clarence, *Brass* 1479, May 1926, alt. 4000 ft. Eastern Division: Fife Bay, *Turner* 95, Sept. 1930 (plant about 4 ft. high); South Cape, *Chalmers* (MEL); "south-east New Guinea," *Chalmers* in 1878; Samarai, *Fitzgerald* 7, common (more or less caespitose, 1-3 ft. high); Dixon's Bay, Rossel Island, *Chalmers & Bridge*, Jan. 1885; islands near the south-east coast, *Armit* in 1884.

SOLOMON ISLANDS: Without definite locality. *Wernhem*, Jan. 1911 (NSW).

NEW HEBRIDES: Without definite locality, *Haer* 65 in 1902 (NSW).

Widely spread from New Guinea and Queensland through Melanesia to eastern Polynesia. Not previously recorded from the Solomon Islands.

This species has usually been called *Scleria margaritifera* Willd., which is a later homonym of *Scleria margaritifera* Gaertn., a name that has been overlooked by most botanists and by the compilers of *Index Kewensis*. Gaertner gave a good account and figure of a portion of the inflorescence, spikelets and fruit. He cited several synonyms, including *Carex lithosperma* L. and *Scleria flagellum-nigrorum* Berg. *Core, Brittonia* 2: 87. 1936, referred Gaertner's name, figure and description to *S. flagellum-nigrorum* Berg., which would seem to be its correct disposition; it is accordingly a superfluous name for this species. Willdenow, *Sp. Pl.* 4: 312. 1805, cited *S. margaritifera* Gaertn. as one of the synonyms of "*Scleria flagellum* Sw.," but on the next page deliberately used the same name for a species which he described as new from a specimen collected by Forster on the island of Tanna. Hence *Scleria margaritifera* Gaertn. and *Scleria margaritifera* Willd. are quite distinct names, and both of them are illegitimate under any circumstance.

I have not seen the types of *S. polycarpa*, *S. graeffeana* or *S. ternifolia*, but I have seen specimens from the type-localities of each that agree with the original descriptions. The species is closely allied to *S. scrobiculata* Nees, differing from it chiefly in the narrower partial panicles with fewer and less spreading branches, the inconspicuous bracteoles shorter than the spikelets, the relatively inconspicuous male spikelets, the more evenly distributed fertile spikelets, the nut more gradually narrowed to the tip and nearly smooth to slightly rugulose at maturity, and the less deeply divided disc with more prominently denticulate margins; the nuts are frequently bright blue with red discs. The leaf-sheaths in both species may be broadly or narrowly winged or quite wingless on different individuals. Both species are robust plants with the middle leaves in false-whorls of three, relatively numerous partial panicles, medium-sized nuts which are also more or less hirtellous, and rather short discs.

The following references to *Scleria scrobiculata* belong wholly or in part to *S. polycarpa*: K. Schum. & Hollr. *Fl. Kaiser Wilhelmsl.* 25. 1889; K. Schum. & Lauterb. *Fl. Deutsch. Schutzgeb. Südsee* 198. 1901; F. M. Bail. *Queensl. Agr. Jour.* 23: 220. 1909; Valck. *Suring. Nova Guin. Bot.* 8: 712. 1912; Kükenth. *Bot. Jahrb.* 59: 58. 1924.

***Scleria poaeformis* Retz. *Obs.* 4: 13. 1786.**

Scleria oryzoides Presl, *Rel. Haenk.* 1: 201. 1830; F. Muell. *Pap. Pl.* 2: 51. 1886.

PAPUA: Western Division: Fly R., *Bäuerlen* 562, Nov. 1885 (MEL); Lake Daviumbu, Middle Fly R., *Brass* 7855, Sept. 1936, in dense pure stands dominating many large swamps on savannahs; Gaima, Lower Fly R. (east bank),

Brass 8261, Nov. 1936, swamps in savannah forest area; Wuroi, Oriomo R.,
Brass 5748, Jan.–March 1934, alt. 10–30 m., in dense formation in a small
 swamp; Daru Island, *Brass* 6338, March 1936, forming pure stands, 1.5 m. tall,
 in shallow open swamp in savannah forest.

Bäuerlen's specimens were cited by F. Mueller, l.c.; Brass's specimens were
 received determined by Kükenthal as *S. oryzoides* Presl. My recent examination
 of the type of *S. poaeformis* (LD) confirmed the opinion expressed by C. E. C.
 Fischer in Kew Bull. 1931: 265. 1931 that this name and *S. oryzoides* are
 synonymous. The species extends from northern Queensland northward and
 westward to India.

Besides the species mentioned in the foregoing pages, the following have
 been recorded for New Guinea, based on specimens that I have not seen:

Scleria hookeriana Boeck.; Kükenth. in Eng. Bot. Jahrb. 59: 59. 1924.
Scleria levis Retz. forma *villosa* Valck. Suring. Nova Guin. Bot. 8: 712.
 1912; Kükenth. Bot. Jahrb. 59: 58. 1924; Ohwi, Bot. Mag. Tokyo
 56: 212–3. 1942.

Scleria brownii Kunth: Kükenth. Bot. Jahrb. 70: 464. 1940.

The record of *S. brownii* is very likely based on specimens of *S. novae-hollandiae* (see under this species); the other records may also be based on
 specimens of species discussed elsewhere in this paper.

The following key will serve to distinguish the species seen from New
 Guinea:

Spikelets — at least the fertile ones — androgynous; disc reduced to an indistinct basal rim or (in *S. motleyi*) more or less cupshaped and thin; nut trigonous.

Annual, lemon-scented; spikelets in small distant clusters along a simple common axis without prominent bracts *S. pergracilis*.

Perennial; inflorescence of terminal and axillary partial panicles with prominent bracts, the partial panicles sometimes spike-like.

Disc rudimentary; nut glabrous.

 Nut quite smooth, even when young *S. lithosperma*.

 Nut rugose, even at extreme maturity *S. roxburghii*.

Disc cup-shaped; nut hirtellous with ferruginous hairs *S. motleyi*.

Spikelets unisexual, the females commonly with one or more empty glumes above the flowers; disc always present, shallowly to deeply 3-lobed; nut not distinctly angular.

Annual plants rarely up to 50 cm. high; culms about 1 mm. wide or less; leaves 1–3 mm. wide.

Nut ellipsoid or cylindroid, not prominently apiculate; terminal partial panicle longer than the others.

Disc deeply divided with nearly separate ovate to oblong, more or less acute lobes; nut deeply tessellate, more or less shining *S. tessellata*.

Disc small and thin, shallowly lobed with broadly rounded lobes; nut dull, smooth or somewhat verrucose or somewhat reticulate *S. novae-hollandiae*.

Nut globular, prominently apiculate, at first reticulate, finally often smooth except for a few tubercles on the upper part; disc thick, shallowly lobed; partial panicles all small. *S. rugosa*.

Perennials up to 3 m. high or more with prominent rhizomes; culms at least 1.5 mm. wide and usually wider; leaves 4–20 mm. wide.

Spikelets mostly in pairs, the lower one of most pairs fertile; inflorescence of 3–8 partial panicles, the lower ones from long, leaf-like bracts; leaves long-tapering to a narrowly obtuse or filiform tip; rhizome more or less knotty with approximated culms.

Ligule longer than (usually 2–3 times as long as) wide; bracteoles unusually prominent and long exserted from the dense partial panicles *S. ciliaris*.

Ligule shorter (usually much shorter) than wide; bracteoles usually less prominent, or setaceous; partial panicles looser-flowered or subspiciform.

Leaves all about equally distributed along the culm; bracteoles prominent.

Disc-lobes lanceolate, more or less acute, more or less toothed *S. levis*.

Disc-lobes broadly rounded, entire *S. terrestris*.

Leaves clustered in groups of 3 (rarely 2) at the base of and below the inflorescence.

Bracteoles nearly as long or as long as the more or less spreading branches of the partial panicles; nuts borne chiefly towards the base of the branches, abruptly rounded below the mucronate tip, commonly deeply scrobiculate and white. *S. scrobiculata*.

Bracteoles inconspicuous, much shorter than the more or less erect branches of the more or less spiciform partial panicles; nuts evenly distributed throughout the partial panicles, rather gradually narrowed to the mucronate tip, rugulose to smooth at maturity, often tinged blue; disc often red. *S. polycarpa*.

Spikelets not paired, evenly distributed along the branchlets, the fertile ones restricted to the lower part of the lower branches; inflorescence of a single pedunculate compound compact terminal panicle; leaves broad, scarcely tapering to the obtusely rounded tips; rhizome elongated with rather distant culms *S. poaeformis*.

Diplacrum R. Brown

Diplacrum caricinum R. Br. Prodr. 241. 1810.

Scleria caricina (R. Br.) Benth. Fl. Austral. 7: 426. 1878; Kükenth. Bot. Jahrb. 69: 261. 1938.

Scleria axillaris Moon, Catal. Pl. Ceylon 62. 1824, *nomen nudum*.

Diplacrum tridentatum Brogn. Duperr. Voy. Bot. t. 26. 1826.

Diplacrum zeylanicum Nees in Wight, Contrib. Bot. Ind. 119. 1834.

Olyra malaccensis Wall. ex Kunth, Enum. Pl. 2: 360. 1837, pro syn.

PAPUA: Western Division: Lake Daviumbu, Middle Fly R., Brass 7842, Sept. 1936, common on wet plains, also in edge of *Tristania* forests.

New for Papua; widely distributed in Malaysia, extending into Ceylon, India, South China and Queensland.

The limits of *Diplacrum* and *Scleria* have been variously circumscribed and the two groups have often been treated as congeneric. A few American species have sometimes been referred to *Diplacrum*, but they are best treated as a separate genus, *Pteroscleria* Nees. The more important characters differentiating the three genera are as follow:

Scleria: Male spikelets (or male portion of androgynous spikelets) borne above the female; stamens commonly 3. Female spikelet: glumes 3-6 below the flower and usually one or more reduced ones above, 1-nerved, the keel not winged, entire at the tip, permanently membranous, persistent after the fall of the ripe nut. Nut smooth or variously reticulate or tuberculate or transversely rugose, the transverse ribbing at least as prominent (usually more prominent) than the vertical. Outer disc usually present. Leaves in the middle of the stem much the longest, the uppermost (bracts of partial panicles) gradually much shorter and narrower, the lower ones gradually reduced to bladeless sheaths. Partial inflorescences in the upper part of the stem, or inflorescence entirely terminal.

Diplacrum: Male spikelets borne below the female; stamen commonly one. Female spikelet: glumes 2, 3-7-nerved, keeled but the keel not winged, more or less 3-lobed or 3-toothed, hardened at maturity and commonly falling with the ripe nut which they enclose; no glumes above the flower. Nut tending to be heavily ribbed vertically, transverse ribs less pronounced or irregular or absent. Outer disc absent. Leaves or bracts all very similar, all or nearly all with axillary heads of spikelets, 1 or 2 basal ones sometimes reduced to sheaths.

Pteroscleria: Male spikelets below the female; stamens commonly 3 in the lower flowers. Female spikelet: glumes 2, the keel prominently winged, otherwise nearly nerveless, entire at the tip, not hardened at maturity (?), persistent (?); no glumes above the flower. Nut tending to be ribbed vertically, but the ribbing faint or obscure. Outer disc absent. Leaves dissimilar, only the upper ones with axillary heads of spikelets.

As thus delimited, *Diplacrum* comprises a group of about five small slender annual species of the Old World Tropics. *Diplacrum carinatum* is the type-species and is the most widely spread. Endemic species occur in Malaya (*D. reticulatum* Holttum), Africa (*D. africanum* C. B. Clarke) and Australia (*D. pygmaeum* [R. Br.] Nees ex Boeck. and another).

Uncinia Persoon

Uncinia riparia R. Br. Prodr. 241. 1810.

NETHERLANDS NEW GUINEA: Mt. Wilhelmina, 7 km. NE. of Wilhelmina-top. Brass & Meyer-Drees 9847, Sept. 1938, alt. 3560 m., common in weak clumps on mossy floor of subalpine forest.

PAPUA: Central Division: Mt. Albert Edward, Brass 4415, May-July 1933, alt. 3680 m., sporadic on floor of forest.

New for New Guinea; previously known from New Zealand, Tasmania and the mountains of the extreme SE. Australian mainland.

The previous records of *Uncinia riparia* from New Guinea refer to other species. That of F. Mueller, Trans. Roy. Soc. Vict. 1 (2): 36. 1889 and of Kükenthal, Pflanzenr. 4 (20), 38: 63. 1909 and Bot. Jahrb. 59: 59. 1924 refer to specimens of *U. sclerophylla* Nelmes, Kew Bull. 1949: 143. 1949. According to Nelmes, l.c., pp. 142-5, Kükenthal's reference in Bot. Jahrb. 69: 261. 1938 was based on collections in which *U. sclerophylla* Nelmes, *U. subtrigona* Nelmes and perhaps another species are represented. The Clemens collections are so badly mixed and sometimes so poor that it is very risky to interpret references by the examination of alleged duplicates.

ADDENDA

In a parcel of old specimens from New Guinea received for determination from the Melbourne Herbarium there were found a specimen of an undescribed species of *Hypolytrum* and a specimen of a species of *Cyperus* previously unrecorded from New Guinea. They are discussed here, together with other corrections and additions to the previous contributions.

Hypolytrum L. C. Richard

Hypolytrum microcarpum sp. nov. PLATE I.

Culmi ex rhizomate brevi caespitosi, circa 50 cm. alti, 2 mm. crassi, triquetri, lateribus concavis striati, angulis anguste obtusis prope apicem scaberuli, ceterum laeves. Folia basalia linearia, chartacea, 6-9 mm. lata, usque 37 cm. longa, basim versus complicata haud vel vix angustata, apice acutata, prope apicem marginibus nervoque mediano scabra, ceterum laetia; folia caulina 2, conspicue vaginantia, summum inflorescentiam superans, basalibus simillima nisi basim versus angustata. Bractae inferiores foliiformes, inflorescentiam superantes. Inflorescentia suboblonga, subcorymbosa, circa 5 cm. longa lataque, multiflora; axis communis angulosa scabra; rami divaricati, usque ad 22 mm. longi, compressi, scabri, prope apicem corymboso-ramosi ramulis nonnullis eodem modo divisis; ramuli ultimi (pedicelli) usque ad 5 mm. longi, filiformes. Spiculae fusco-brunneae obovoideae vel oblongae, 3.5-4 mm. longae, sub flore circa 2 mm. sub fructu circa 3 mm. latae, pauciflorae. Glumae (explanatae) orbiculari-ovatae, muticae, brunneae, marginibus (apice ipso excepto) subscariosae, 1.3-1.5 mm. longae. Flores 1.3 mm. longi; squamellae more generis 2, liberae, carina parce ciliatae, explanatae lanceolatae obtusae, circa 1.3 mm. longae. Nux subglobosa, leviter compressa, circa 1.4-1.5 mm. longa, 1.3-1.4 mm. lata, brevissime umbonato-rostrata, bicostulata, irregulariter laxaque ruguloso-reticulata, dilute flavo-brunnea sed creberrime rubropunctata.



HYPOLYTRUM MICROCARPUM S. T. BLAKE

PAPUA: Eastern Division: Cloudy Mountains near South Cape, *Chalmers & Bridge* in 1884 (TYPE in MEL).

The description is based on a single specimen consisting of a fruiting culm and two innovation-shoots all attached to the rhizome. It has the habit and general appearance of *H. latifolium* L. C. Rich., *H. scirpooides* (Presl) Merr. (*H. philippense* C. B. Clarke), *H. scabrum* Uitt. and *H. vitiense* C. B. Clarke, but it differs from all of these in the much smaller spikelets, glumes, flowers and nuts and the nearly globular nut with its beak reduced to a very small umbo. The nearly smooth leaves and stem further distinguish it from *H. scirpoideum* and *H. scabridum* and the wrinkling on the nut from *H. vitiense*. It must also be closely allied to *H. minus* Ridl.: I have seen no specimen of this species, and although Ridley's description leaves much to the imagination, the stress placed on the scabrous margins of the much broader leaves suggests that it is closer to *H. scirpoideum* or identical with this, as suggested by Küenthal, Bot. Jahrb. 59: 53. 1924.

Cyperus Linnaeus

Cyperus cinereobrunneus Küenthal. Mitteil. Thüring. Bot. Ver. N. F. 50: 3. 1943; Küenthal, ex S. T. Blake, Jour. Arnold Arb. 28: 216. 1947.

I had not seen Küenthal's paper when I published his name in 1947.

Cyperus globosus All.; S. T. Blake, Jour. Arnold Arb. 28: 220. 1947.

Cyperus globosus All. var. *oblonginuix* Küenthal. Mitteil. Thüring. Bot. Ver. N. F. 50: 7. 1943.

I had mentioned (l.c.) that, in the determination on the label, Küenthal had distinguished *Brass 8309* as a variety; I had not then seen the description. These plants seem to be no more than an individual variation.

Cyperus fulvus R. Br. var. *confusus* (C. B. Clarke) Küenthal. Pflanz. Z. 4 (20), 101: 456. 1936.

Mariscus fulvus (R. Br.) C. B. Clarke var. *confusus* C. B. Clarke ex Domin, Biblioth. Bot. 85: 444. 1915.

PAPUA: Central Division: Quaipo, *MacGregor* in 1889 (MEL).

The species is new for New Guinea, but is common and widely spread

PLATE I

Hypolytrum microcarpum S. T. Blake. Type specimen \times about $\frac{1}{2}$ with analytical drawings. Fig. 1. Glume. Fig. 2. Nut. Fig. 3. Transverse section of nut. All figures \times about 10. Analytical drawings by S. T. Blake, photography by G. Cripps. Photographic Section, Department of Agriculture and Stock, Brisbane.

in NE. Australia. Although quite variable, it is doubtful how much importance can be assigned to the varieties that have been described.

Schoenus Linnaeus

Schoenus maschalinus R. & S. Syst. Veg. 2: 77. 1817; S. T. Blake, Proc. Roy. Soc. Queensl. 60: 47. 1950.

Schoenus foliatus (Hook. f.) S. T. Blake; S. T. Blake, Jour. Arnold Arb. 29: 93. 1948.

Later botanists have overlooked the fact that Roemer and Schultes correctly gave a new name to *Chaetospora axillaris* R. Br. when this was transferred to *Schoenus*. An extensive and complicated synonymy has become associated with the species, which has been discussed in my papers cited above.

Rhynchospora Vahl

Rhynchospora triflora Vahl; S. T. Blake, Jour. Arnold Arb. 29: 101. 1948.

Rhynchospora triflora Vahl var. *papuana* Kükenth. Bot. Jahrb. 74: 427. 1949.

Rhynchospora triflora var. *papuana* was founded entirely upon Brass 8356; I cannot distinguish our specimen of this from our specimen of Henderson in Singapore Field no. 24101 which Kükenthal cited under *R. triflora*.

Carex Linnaeus

Several emendations to my determinations in Jour. Arnold Arb. 28: 99–116. 1947 appeared in a paper by E. Nelmes in Kew Bull. 1949: 378–386. 1949. This was followed by a revision of the Malaysian species in Reinwardtia 1: 221–450. 1951. As pointed out in the introduction to my paper, I had to place considerable reliance on descriptions only; Mr. Nelmes has had a much wider experience in this genus, and his opinions should have preference.

QUEENSLAND HERBARIUM,
BRISBANE, QUEENSLAND, AUSTRALIA.

PREVERNAL LEAFING OF ASPEN IN UTAH MOUNTAINS

WALTER P. COTTAM

With two plates

THE ROCKY MOUNTAIN ASPEN (*Populus tremuloides* Michx., var. *aurea* Tidestrom) dominates more mountainous terrain in Utah at elevations between 7,000 and 10,000 feet than any other forest species. Several features of its growth-form, together with its peculiar autecology and synecology, make this species a very conspicuous forest type. Unlike all other prominent forest species with which it may be associated, such as Douglas fir, white fir, alpine fir, blue spruce, Engelmann spruce, ponderosa pine and lodgepole pine, the aspen is deciduous in habit.

Often the aspen occurs in almost pure stands, which may vary in size from a few square rods to several square miles of solid forest. But whether small or large, the aspen stands are sharply discontinuous, single aged and usually dense. The shiny green leaves of summer, the multi-colored shades of yellow in autumn, and the slender, straight, white boles at all seasons of the year are features of the aspen that set it apart in contrast to all contiguous association types, whether mountain conifers or browse.

But the contrast that exists between the aspen stands and other mountain vegetation types is often exceeded, in early spring at least, by striking differences in the time of leafing within the aspen groves themselves. This phenomenon is widespread throughout the mountains of Utah and neighboring states. In early spring almost any aspen forest shows sharply discontinuous colonies of trees that attain full leaf two or three weeks earlier than the major surrounding stand in which at any other time they are likely to remain unnoticed except by the critical observer.

At mid-elevations these colonies of prevernal aspen are usually small in comparison with the forest as a whole, and their outline is variable. Frequently they assume a circular shape, but they may be seen as a narrow, serpentine band bisecting large groves. In general, the position of these prevernal colonies seems to have no correlation with slope, exposure, soil, altitude, or sex of trees, but wherever they occur or whatever shape they may assume, the line that separates them from the retarded major population of trees is sharp, and rarely do the two forms intermingle as individuals.

CONTROLS OF PREVERNAL LEAFING

For years the author has been intrigued with the causes underlying the prevernal leafing of aspen colonies and surprised at the lack of textbook reference to this phenomenon. But few facts of aspen ecology

escaped the critical eye and pen of F. S. Baker, who in 1921 wrote an excellent description of the prevernal leafing of aspen colonies with special reference to the Wasatch Plateau of central Utah. His paper (4), entitled "Two Races of Aspen," points out certain taxonomic differences between early- and late-leafing stands and concludes: "The writer confesses an entire inability to explain the causes of these two widely distributed and closely intermingled races of aspen." Yet throughout the article Baker implies that the causes, whatever they may be, are genetic and never environmental.

There can be little doubt that at least two and probably several races of aspen exist that show striking differences in time of leafing. Evidence of these strains is seen in the variable combinations of certain morphological characters often associated with the physiological functions that regulate leafing response. These morphological characters are sufficiently distinct and constant as to enable one to distinguish the races at the seasons of the year when leaf color and size no longer offer safe clues to their identity. For example, Baker pointed out that in the Wasatch Plateau area boles of the early variety are yellow-green in color in contrast to the powdery-white appearance of the late-leafing variety. The writer has found no exception to this phenomenon throughout the northern half of Utah. This bole color difference is due to the failure of the early-leafing form to produce the usual copious bloom on the bark exterior characteristic of the late-leafing variety.

Another character generally useful in distinguishing the leafing strains of aspen is the pruning habit of the trees. In central and northern Utah, early-leafing aspens in general fail to prune themselves of the lower, small, dead branches on the trunk, thereby presenting an appearance of low vigor and untidiness entirely foreign to the late-leafing strain. (Careful observation, however, discloses that this lack of vigor is more apparent than real.)

Thus, in central and northern Utah, prevernal leafing of aspen is associated with the apparently genetic characters of yellow boles and poor pruning. However, on the Aquarius Plateau of south central Utah, the early-leafing character is associated with white boles and clean pruning, while the late-leafing trees are yellow-boled, non-pruning, a complete reversal of genetic alignment of the northern form.

In distribution within the aspen belt, early-leafing varieties dominate the higher elevations only. At the upper limits of the belt, aspens exist mainly as dwarfed thickets, which are always of the early-leafing forms as distinguished, of course, by the bole color and pruning habit. Conversely, the lower limits of the aspen belt are dominated by late-leafing varieties. Thus the contrast between early- and late-leafing aspens is most pronounced in the spring at mid-elevations, where the two forms are often intermingled as colonies. Here also is found the greatest contrast in autumn, for the early-leafing forms, as a rule, maintain their green color several days longer in the fall than do the late-leafing varieties.

For several years the writer has observed a few areas where contiguous colonies of early- and late-leafing aspen fail to present the morphological

differences mentioned above. In all of these exceptions the boles of both aspen groups are white and well pruned, yet the length of the leafing time differences is the usual two to three weeks. One such area is located at the head of South Willow Creek Canyon in the Stansbury Mountains, approximately fifty miles west of Salt Lake City. Another is found in the Abajo Mountains west of Monticello in southeastern Utah. Both areas occur at an elevation of about 7,500 feet.

TEMPERATURE CONTROLS OF PREVERNAL LEAFING

The Stansbury group appears at the bottom of an east-west canyon at a point where the generally straight canyon forks abruptly. The major fork heads south and in a circuitous manner drains the summit of the 10,000 foot range. The minor fork proceeds west for approximately one mile where it ends more or less abruptly, forming a sort of "boxed" segment rather well protected from air drainage from the summit above. Each spring in late May, aspens in this box canyon may be seen in almost full leaf with a sharp line scarcely more than a rod wide bisecting the grove and separating those in leaf from a half mile area of leafless aspens lying at and below the confluence of the major south fork.

Here there is an anomalous condition in which a grove of aspens leaf out considerably before their neighbors two to three hundred feet below them in elevation. In order to ascertain whether temperature might be a controlling factor in this phenomenon, a transect of four stations (two above and two below the leafing line) was established. Recording thermographs, fastened to the aspen branches ten feet above the ground and protected by white canvas tents, were used in this preliminary experiment, as well as in others to be reported below. Readings were begun May 7 and terminated May 19, 1951. During this period neither group of aspen had progressed beyond the swollen bud stage. Figure I shows the daily minimum, maximum and mean temperatures in both aspen groups over this period of 13 days.

The comparative summaries given in Figure I leave little doubt that these two major stands of aspen, showing marked differences in the time of leafing, exist under strict temperature controls and are not separate races. Considering the fact that the early-leaving aspen while occupying the higher elevations show a daily mean temperature two to three degrees greater than the late-leaving stands, these temperature differences seem highly significant. Translated into altitudinal effects, the temperature difference between these two aspen groups is equivalent to approximately 1000 feet in elevation. Furthermore, observations in this area in early June, 1951, disclosed several typical prevernal colonies of genetically controlled aspen within the major retarded zone of lower temperature. These small isolated colonies of yellow-boled aspen came into leaf at approximately the same time as the large stand of white-boled aspen of the higher temperature area.

GENETIC CONTROLS OF PREVERNAL LEAFING

Circumstances prevented the writer from visiting the prevernal leafing aspen colonies of the Abajo Mountains of southeastern Utah until August, 1951. With the aid of kodachrome pictures taken in May, 1950, the exact position of these colonies was ascertained. Comparative temperature records were taken for a period of four days. No significant temperature differences between the early-leafing and late-leafing stands were found. The uniformity of the topographical features suggests, moreover, that there should be none. While considerably more temperature data are needed for this area, the evidence points to the probability that early-leafing and late-leafing colonies of aspen here represent different genetic strains unassociated with observable bole and pruning characters.

Continuous temperature data from June 1 to September 30, 1951, except for two interruptions of four days each, were secured from contiguous colonies of prevernal and late-leafing aspen at Mt. Timpanogos located in the Wasatch Range 30 miles southeast of Salt Lake City. These colonies, occupying mid-altitudinal positions of about 8,000 feet, all showed the morphological differences described earlier, as well as the

FIGURE I

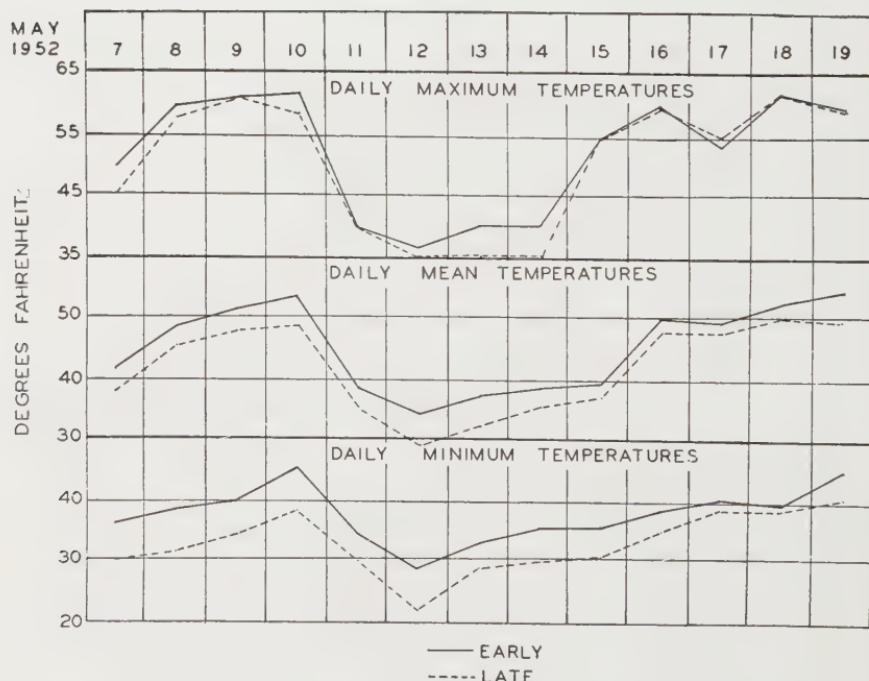


FIG. I. Temperature phenomena of adjacent stands of early- and late-leafing aspen, Stansbury Mountains, Utah. Solid lines early. Broken lines late.

conspicuous differences in leafing time. Figure II represents weekly summaries of the averages of temperature data for two stations each in a pair of contrasting colonies selected for their apparent uniformity of soil and topographical features. Intermittent data from two other pairs of contrasting colonies were also secured throughout the summer. These confirmed the results shown in Figure II.

The data in Figure II reveal that the maximum weekly temperature averaged slightly higher and the minimum temperature averaged slightly lower in the late-leaving colony than in the early-leaving stand, although the mean weekly temperature averages were essentially similar in both. These slight temperature differences may be accounted for by the fact that the late-leaving stand, being slightly more open than the early-leaving colony, allows more sun on the tents by day as well as more effective air circulation by night. However, no aspect of these temperature phenomena is sufficient to account for the great discrepancy of leafing time for these colonies, and the conclusion seems justified that the cause of prevernal leafing lies outside of environmental controls.

FIGURE II

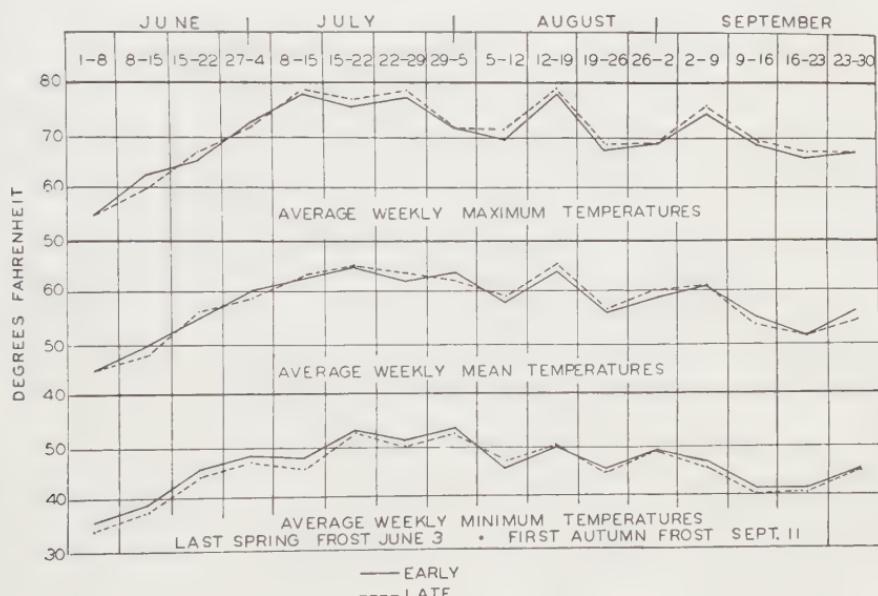


FIG. II. Temperature phenomena of adjacent stands of early- and late-leaving aspen, Mt. Timpanogos, Utah. Solid lines early. Broken lines late.

In order to test the hypothesis that the two distinct leafing forms of aspens possessing recognizable morphological differences at Mt. Timpanogos are true genetic races, other methods of approach seemed desirable: First, the transplanting of aspens from one colony to another, as well as

to a common habitat; second, investigations on the clonal features of the aspen; and third, cytological studies.

TRANSPLANTING EXPERIMENTS

Eight aspen sprouts from three separate pairs of colonies were transplanted in the fall of 1951, thereby introducing into prevernal colonies twelve late-leafing saplings and into late-leafing colonies an equal number of early-leafing saplings. Despite the fact that care was exercised to locate the transplants on the edge of the colonies where competition for light and moisture could be reduced to a minimum, none of the aspen sprouts survived the winter and summer of 1952.

In this experiment it was recognized that several years must elapse before conclusive results might be expected, assuming successful transplantings were possible, because observations have disclosed the fact that aspen sprouts must attain considerable height before they acquire either the morphological characters or the leafing peculiarities of the mature stand. The retarding of the leafing time of the sprouts in prevernal colonies is especially noticeable and may be accounted for by the fact that leafing of the mature trees is generally well advanced before the snow pack has disappeared from the stand. Obviously the close proximity of the snow to the sapling buds has a retarding effect on leafing.

In addition to these transplantings in the field, four saplings from late-leafing aspen stands and four saplings from early-leafing colonies were removed to the University of Utah campus, where previous transplantings of aspen sprouts have proved successful. These transplants were made in late May, 1952, to a favorable situation where nearly uniform factors of soil, water and light were maintained for all saplings.

Three saplings from the late-leafing variety and two from the early survived the summer of 1952 and the winter of 1953. In the spring of 1953 both early-leafing sprouts came into leaf more than two weeks before the late-leafing transplants. Thus the leafing character of the two mountain strains was maintained under totally different environment, and the hypothesis of genetic controls received considerable support.

CLONAL CONNECTIONS OF ASPEN COLONIES

It was assumed that if the present strains of aspen had their origin in seed mutation, contiguous colonies of early- and late-leafing forms should show no clonal connections, although such connections might be expected to exist between trees within the same colony. To determine the nature and extent of aspen clonal connections, at Mt. Timpanogos radioactive phosphorus was employed.*

Selected for radioactive phosphorus treatment was a white-boled, late-leafing tree which occupied a position between closely contiguous colonies of distinct strains of aspen. On one side the branches of this tree inter-

* The writer is indebted to the Research Committee, University of Utah, for supplying the necessary radioactive phosphorus used in this experiment; to Dr. Robert C. Pendleton for labeling the tree; and to Dr. John D. Spikes for monitoring the laboratory specimens.

mingled with those of early-leaving trees and on the other with branches of late-leaving individuals. The nearest bole of the late-leaving variety was 7 feet 6 inches distant, and the nearest bole of the early variety was 6 feet 6 inches. There were six early-leaving trees and seven late-leaving ones within a radius of 17 feet. Near the tree selected for labeling, a trench was excavated exposing the roots, one of which was severed about three feet from the bole. The cut end of this root was inserted into a gallon jar of water containing 40 millicuries of radioactive phosphorus (P-32).

Within 36 hours most of the radioactive phosphorus solution had been absorbed by the tree. The tube of a Geiger counter was placed in a rectangular hole cut breast high in the bark of the labeled tree, thereby exposing the cambium. The counter showed a radioactivity of 60,000 counts per minute. No other tree of either variety in the vicinity of the labeled tree showed radioactivity above background. In subsequent days portions of the roots, cambium, wood and leaves of the labeled tree and of the early- and late-leaving trees surrounding it were removed to the laboratory. These specimens were ashed and tested with a standard scaler provided with a thin-end, window Geiger tube. All ashed samples from the labeled tree gave more than 50,000 counts per minute. No radioactivity above background was found in the samples of any other tree. Excavations around the labeled tree showed that all roots belonging to the labeled tree were radioactive, but that the radioactive substance had not passed to the roots of neighboring trees of either strain.

The results of this experiment are indeed surprising, for they suggest complete separation of the aspen sprouts from the parent clone before or soon after maturity. Considerably more investigation is necessary to establish the clonal characteristics of the aspen.

CYTOTOLOGICAL TESTS

The field of cytogenetics should offer an interesting and possibly a fruitful approach to the problem of the leafing strains of aspen. So far, however, the writer has encountered perplexing delays in securing suitable tissue for study. Because of the unreliability of aspen seed production, and the major difficulties of securing pollen smears from the remote and snow-bound experimental area, it was assumed that cuttings would provide the most feasible source for securing tissue in active cell division. Numerous greenhouse attempts have been made to root aspen cuttings without a single positive result to date. Additional effort to secure root tips for study is currently in progress.

Positive microscopic evidence of chromosome aberrations would, of course, establish the validity of these genetic strains, but negative evidence would not necessarily preclude it, for mutations may be the result of one or a few unobservable gene changes.

DISCUSSION

Whether cytologically demonstrable or not, the fact or the assumption that these readily distinguishable forms of early- and late-leaving aspen

represent mutant strains presents problems of origin and subsequent distribution both interesting and perplexing to the ecologist. For no fact of aspen ecology, in Utah at least, seems more certain than that aspen trees in general, despite occasional abundant viable seed production, reproduce only through vegetative means. They do this because aspen seeds must germinate within a few weeks after ripening in early June. Under present climatic conditions precipitation in Utah is invariably scant and irregular during the summer months. Thus the wide and spotty distribution of aspen throughout Utah today must have been attained under climatic patterns of more abundant and more evenly distributed summer precipitation. Such conditions are postulated by geologists for the Great Basin region during the pluvials associated with the extensive Pleistocene glaciations (1, 2 & 3).

After the onset of the Postpluvial climate in the Great Basin area, which Antevs estimates at approximately 8,000 years ago, it is likely that aspen ceased its reproduction by seeds. Since then migration has been through clonal reproduction only, and exceedingly slow, but sufficient to effect the mergence of many previously separated colonies and to extend the upper altitudinal limits of the aspen belt. Conversely, the increased temperature and lower summer precipitation of the Postpluvial may have caused considerable retreating migration from lower limits of the Pluvial aspen distribution. There are examples of the complete disappearance of aspen colonies at lower elevations during historical times, but grazing influence may have been a contributing cause.

Any proposed hypothesis to explain the origin and present-day distribution of early- and late-leafing aspens must account for the following facts:

1. The predominance of late-leafing forms at low and mid-elevations.
2. The predominance of early-leafing aspen at higher elevations.
3. The widely intermingled colonies of the two forms at mid-elevations, their sharp discontinuity and the purity of their stands.

Assuming that mutations have occurred within the sex cells and therefore have involved successful seedling establishment, it must follow that the mutant strains date back to Pluvial times. Since the altitudinal migration of aspen in Postpluvial times has been mainly upward, and since the late-leafing strain dominates the lower aspen elevations today, the late-leafing form must be the parent type.

It seems obvious that a longer photosynthetic period (upwards of three weeks) acquired by the mutant strains would give them distinct physiological survival advantages over the parent form, particularly at higher elevations where the frost-free period is short, provided, of course, that they also possessed adaptive resistance to lower temperatures. The ability of the early-leafing form to withstand frost in spring is apparent because banks of snow are frequently present beneath the aspen canopy when these trees come into leaf. Temperature records in the early-leafing experimental colony at Mt. Timpanogos, with no snow on the ground in 1951, showed night temperatures of 30° F. or below for a period of approximately

nine hours duration each for June 1, 2 and 3. On the night of June 1, 1951, the minimal temperature of 26° F. prevailed for approximately three hours. The aspen leaves in the early-leaving colony at this time were about one half mature size, while the adjacent late-leaving trees were still in the bud stage.

Whether or not this insensitivity to mild freezing temperature is merely another expression of the same mutation that produced early leafing would be difficult to determine, but certainly the prevernal appearance of aspen leaves would be impossible without this adaptation. That the same degree of frost resistance is not possessed by the late-leaving form is suggested by its apparent inability to invade the upper limits of the aspen belt, by its failure to produce leaves at mid-elevations until the frost period is over and by its habit of dropping leaves earlier in the fall than the early-leaving varieties growing in similar habitats.

At mid-elevations it is apparent that both strains of aspen successfully established seedlings at the close of Pluvial times after these mountain areas had been cleared of the receding ice. It is probable that at lower elevations, high temperature and drought were more limiting as factors of successful aspen establishment than a longer photosynthetic period. Also, suitable sites for aspen were already occupied by the late-leaving parent type. Assuming that neither strain had significant advantage at mid-elevations, the preponderance of seed of the late-leaving strain would account for the dominance of the late-leaving form at mid-elevations today. Clonal reproduction over the centuries of Postpluvial time from trees of these two strains as loci for vegetative migration has, in many instances, brought about the mergence of these two contrasting leafing forms into a single forest stand.

A critical test of this hypothesis awaited the experiment using radioactive phosphorus to trace the clonal relationship of the two strains. It was postulated that a solution of radioactive phosphorus applied to the roots of an aspen of either strain, situated at the line of contact of the diverse colonies, should, according to the hypothesis, pass freely through the root connections to neighboring trees of its own strain, but never to the trees of the opposite strain regardless of their proximity to the labeled tree. The one experiment performed thus far is therefore disappointing as evidence for or against the hypothesis in that it suggests that mature aspen trees in a colony sever their clonal connections.

SUMMARY

1. Almost any aspen forest in early spring in Utah and neighboring states shows sharply discontinuous colonies of trees that attain full leaf two to three weeks earlier than the major stand that surrounds them. The colonies of prevernal aspen are usually small in comparison with the forest as a whole, and in general they are most pronounced at mid-elevations of the aspen belt.
2. Extensive data secured with recording thermographs show that one segment of an aspen forest exhibiting prevernal leafing, is a response to

temperature controls, but that in general the early-leaving colonies of aspen represent distinct genetic strains in which temperature is not a factor.

3. As a rule the leafing habit of the various aspen strains is associated with morphological characters by which they may be identified at all seasons.

4. Saplings of early- and late-leaving strains of aspen transplanted to the University of Utah campus at an elevation of 4,500 feet exhibited the same time difference in leafing as their parent colonies at 7,800 feet.

5. An hypothesis proposed to explain the origin, present distribution and nature of prevernal aspen colonies postulated the following:

- (a) Sexual mutations of the late-leaving parent type occurred in Pluvial times.
- (b) Migration to and establishment of these strains at higher elevations followed the disappearance of mountain ice and snow packs.
- (c) Early-leaving forms dominate the upper limits of the aspen belt because of their longer photosynthetic period and their physiological adaptations to lower temperatures.
- (d) Clonal reproduction over the centuries of Postglacial time from seed-established trees as loci for vegetative migration has produced the mergence of these contrasting leafing strains into single forest stands.

UNIVERSITY OF UTAH,
SALT LAKE CITY, UTAH.

LITERATURE CITED

1. ANTEVS, ERNST 1948. Climatic changes and pre-whiteman. *The Great Basin*. Bull. Univ. Utah **38** (20): 168-191.
2. ——— 1952. Cenozoic climates of the Great Basin. *Geologischen Rundschau* **40** (1): 94-108.
3. ——— 1952. *Univ. Calif. Archaeol. Surv. Reports*, No. 16, p. 23.
4. BAKER, F. S. 1921. Two Races of Aspen. *Jour. Forestry* **19** (4): 412-413.

EXPLANATION OF PLATES

PLATE I

Typical stands of early- and late-leaving aspens, mid-elevation (7800 feet). Mt. Timpanogos, Utah. In the right mid-ground is seen the protective tent covering for one of the recording thermographs used to compare atmospheric temperature phenomena of the contiguous aspen strains.

PLATE II

Late-leaving aspens (foreground) have white, well-pruned boles in northern Utah, while the early-leaving forms (background) are yellow-boled and poorly pruned.



PREVERNAL LEAFING OF ASPEN IN UTAH MOUNTAINS



PREVERNAL LEAFING OF ASPEN IN UTAH MOUNTAINS

THE CONTROL OF TREE GROWTH BY PHLOEM BLOCKS

KARL SAX

With one plate

THE NATURE OF SAP MOVEMENT, nutrient transport and stem polarity in plants has long been known. Thomas Andrew Knight reporting in the Transactions of the Horticultural Society of London in 1822 observed that "the vessels of plants are not equally well calculated to carry their contents in opposite directions" and that "the true sap of trees is wholly generated in the leaves, from which it descends through their bark to the extremities of their roots, depositing in its course the matter which is successively added to the tree." Thus Knight recognized polarity in the transport of elaborated nutrients down the phloem based upon his experiments with inverted cuttings and the effect of girdling the bark of fruit trees. He observed that "it had long been known to gardeners, that taking off a portion of bark round the branch of a fruit-tree occasions the production of much blossom on every part of that branch in the succeeding season." He concluded that the effect of dwarfing stocks in promoting early fruiting and restricting tree growth was similar in nature to the effect of girdling the bark and attributed both effects to the "obstruction of the descending sap."

Phloem blocks induced by killing the stem with steam were used by Dixon (8) and others in their studies on the ascent of sap. The fact that the sap passed up the xylem of the dead stem provided evidence for the "mechanistic" rather than the "vitalistic" theory of the ascent of sap. More recently it has been shown that phloem blocks, induced by killing a section of the stem with heat, prevent the downward movement of vitamins, organic carbohydrates and growth-regulators (Crafts 1951). Bonner (4) girdled the stems of tomato plants with a jet of superheated steam which killed all living tissue. In a few days he found an accumulation of thiamin, pyridoxine, pantothenic acid, riboflavin, sucrose and nitrogen above the girdle. Rabideau and Burr (11) killed sections of bean stems with hot wax and used radioactive carbon to trace the flow of photosynthetic products down the stem. Most of the elaborated organic material accumulated at the dead segment. A phloem block in *Phaseolus* also checked the movement of growth-regulators such as 2,4-D as shown by Weintraub and Brown (15).

It is, however, unnecessary to kill a segment of the stem in order to induce a phloem block. Christensen (5) found that irradiation of a stem segment with X-rays was followed by a swelling of the stem above the irradiated section, and after four or five weeks the swollen area developed roots if the stems were kept moist. The minimum dosage required for such a response was 1500 r for *Xanthium*. Similar results were obtained

with *Nicotiana* at 6000 r, *Lycopersicum* at 24,000 r, and *Phaseolus* at 16,000 r, but the minimum dosage required to induce a response was not determined in these genera. The phloem block induced by irradiation checked the flow of organic materials and auxin down the phloem without killing the stem segment.

It is also possible to impose a phloem block without killing the stem by inverting the scion or by inverting a ring of bark. This technique is based upon the polarity of phloem transport. The botanical studies of stem polarity date back to the work of Vöctung and Sachs with their description of "root-pole" and "shoot-pole." The role of polarity in grafting was probably known by horticulturists for hundreds of years. It was described by the botanist Strasburger (14) as follows—"Unlike poles of a plant may readily be induced to grow together, while like poles may only be brought to do so with difficulty and then do not develop vigorously." This conclusion has been confirmed repeatedly. The inversion of the rootstock has, however, been used to stimulate rooting at the base of the scion in order to get varieties of apple trees on their own roots. Kerr (10) found that such an inverted graft would survive long enough to permit scion rooting above the graft union, due presumably to the accumulation of auxin at the junction of the "root-poles" of stock and scion.

The induction of a phloem block by inverting a ring of bark was reported in 1935, but it is probable that it was also used by the early horticulturists of Europe. According to Roberts (12) the inverted rings checked the growth of the tree, but without the deleterious effect resulting from girdling. Apparently this work was not continued by Roberts.

It is also known that certain incompatible combinations of stock and scion check tree growth as a result of a phloem block induced by an imperfect graft union (2). In some cases, however, the graft union appears to be normal yet there is considerable overgrowth of the scion accompanied by dwarfed growth and precocious fruiting. In these cases perhaps the stem of the scion can utilize the organic carbohydrates from its leaves more effectively than can the stem of the rootstock.

There is some evidence that the dwarfing effect of certain Malling apple rootstocks may be due to a retardation of phloem transport. Dr. F. R. Tubbs, Director of the East Malling Research Station, writes that: "We do not know of any dwarfing apple rootstock that does not induce the formation of a bulge" (personal communication). This swelling of the stem of the rootstock or the section of the interstock could be attributed to the retardation of the downward flow of elaborated organic nutrients and growth stimulants, as suggested by Knight, thus promoting more rapid growth of the Malling rootstock or interstock stem. The fact that a long dwarfing interstock is more effective than a short one, and that certain rootstocks are more dwarfing if budded high on the stem than if budded near the ground, would seem to support the above interpretation (13).

It is known that the dwarfing effects of certain rootstocks are due to factors other than the blocking or retardation of phloem transport. Colby (6) has suggested that the extreme dwarfing effect of the Malling IX

apple rootstock may be due to early suberization of the young roots. There is also evidence that growth can be suppressed, quite independently of the nature of the graft union, by an interaction between the scion variety and the root system of the stock (Sax, Proc. Am. Soc. Hort. Sci., in press).

During the past five years a study of the effect of inverting rings of bark has provided some information on the mechanism of phloem transport and has provided another method for dwarfing fruit and ornamental trees. We began with the inversion of a single ring of bark about an inch long on the stems of one- and two-year-old apple trees. The cuts through the bark were made as parallel as possible, sometimes by using a double bladed knife—in other cases by using a strip of metal tape as a guide. The bark was removed, inverted and wrapped tightly with a rubber band, until the bark had healed onto the stem—a period of a week or ten days.

The inverted bark made little or no growth, but there was a swelling of the stem above the inverted bark and to a lesser extent at the upper edge of the inverted section of bark. At the vertical seam of the inverted ring there was regeneration of tissue and after several months this area had made considerable growth, and after several years it had so dominated the inverted area that the dwarfing effect was largely lost. Apparently there is normal polarity of phloem transport in this regenerated area and it grows rapidly.

In order to effect a more permanent phloem block it was necessary to invert two rings of bark, one directly above the other, and orient the vertical seams on opposite sides of the stem. There is some phloem regeneration at the seams, but any downward transport through the seam of the upper inverted ring is checked when it reaches the intact edge of the lower inverted ring with its vertical seam on the opposite side. A Cortland apple whip was treated in this way five years ago. It has made almost no growth in trunk diameter and has increased in height only about six inches during the past five years, but it has borne several fruits during each of the past two years and appears to be healthy.

In 1953, a group of Baldwin apple trees, budded on a semi-dwarfing rootstock, were used for a bark inversion test. A single ring of bark was inverted on eight two-year-old trees, and above the vertical seam a square of bark was inverted to prevent transport down the regenerated tissue. In the eight controls a ring of bark was removed and replaced in the normal position. In both the bark inversion series and in the controls there was some early sucker growth below the rings, and the first growth of suckers were removed. Subsequent sucker growth was limited almost entirely to the trees with inverted bark. At the end of the growing season the trunk diameter below the bark ring was measured, together with tree height and total length of the branches developed below the inverted bark rings. The results are shown in Table 1, and photographs of a control and of an inverted bark tree are shown in Figures 1 and 2.

The data show that the inversion of the ring of bark reduced the growth of the trees both in trunk diameter and in height. It also promoted the growth of buds below the phloem block, indicating that the auxins

which normally suppress bud development at the base of the trunk had not passed through the inverted ring of bark in sufficient quantities to suppress bud growth. Most of the trees with the inverted bark have flower buds while no flower buds were observed on the control trees. The inverted bark remains alive, so far as can be determined by its appearance, yet growth is suppressed and earlier fruiting is induced.

TABLE 1.
EFFECT OF BARK INVERSION ON TREE GROWTH
Baldwin/524/sikkimensis.
Bark inverted June 1, '53. Measured Oct. 6, '53.

8 Controls			8 Inverted		
Trunk Caliper cm.	Height Feet	Sucker Growth ft.	Trunk Caliper cm.	Height Feet	Sucker Growth ft.
2.0	4.5	0	1.5	3.8	4.1
1.7	5.1	0	1.1	3.1	4.2
1.9	4.6	0	1.4	3.2	4.5
2.1	4.9	0	1.4	3.2	5.1
1.9	4.5	0	1.4	3.1	4.9
1.9	4.0	0	1.6	3.5	2.1
1.6	4.2	0.5	1.5	3.5	3.2
2.1	4.1	0	1.5	3.6	4.7
Ave. 1.9	4.5	-0.1	1.4	3.4	4.1

It should be possible to modify the bark inversion phloem block to permit the desired amount of growth of the tree. A method developed several years ago appears to meet this need. Baldwin two-year-old trees, budded on *Malus sikkimensis* rootstocks, were used. Two bark inversions were made with eight-inch strips of normal bark on opposite sides of the trunk, and the inverted rings were separated by a short segment of normal bark of half an inch to one inch in length. The downward movement through the phloem was limited to the slender strip of normally oriented bark. After passing down the first ring the flow must pass laterally before it can pass down the normal strip of bark in the second ring. Although lateral phloem transport is restricted some material does get through as is evident from the growth shown in Figure 4. It is probable that a short section of normal bark between the inverted rings would have a greater restriction on phloem transport than a long one, so that the degree of dwarfing could be regulated to some extent by varying the length of the central segment between the inverted rings. Thus by adjusting the width of the normal strips of bark in the inverted rings and by varying the length of the normal central segment, it should be possible to obtain any desired degree of dwarfing.

All of these treated trees flowered and several bore fruit the following

year. One of these trees, bearing abundant flower buds as it begins its fourth season's growth, is shown in Figure 3. The details of the double bark inversion are shown in Figure 4. The growth of the normally polarized strips of bark in the inverted rings may eventually result in a direct line of phloem transport through the normal ring of bark between the inverted segments, and the dwarfing effect will be reduced and finally lost. In order to maintain a permanent dwarfing effect the inverted bark technique may have to be repeated, but when a tree reaches the desired size a double inversion with only a very narrow ring of bark (or none at all) between the inverted rings, should insure permanent dwarfing. Since the bark inversion may have to be repeated, this technique for dwarfing trees is not likely to be of much value to the commercial nurseryman. The average back yard horticulturist should, however, have no trouble in using this technique.

In a few cases we have put double upside-down adjacent rings on larger trees (up to 6 inches in diameter) with the hope that further growth could be checked almost completely and yet permit flowering and fruiting. These trees have been treated only for one growing season, and at least several years must elapse before we can recommend such a procedure.

The inactivation of the phloem by ionizing radiation is comparable in several respects to the effects of inverting a ring of bark. The phloem block is induced without killing the bark, swelling of the stem occurs above the treated area and bud growth is stimulated below the phloem block just as it is by inverting the bark. On July 27 the stems of a clonal line of young poplar trees were irradiated with 2,500, 5,000 and 10,000 roentgen units of X-rays respectively. A lead plate with a 1.5 inch slit was placed over the stems to limit the radiation to the short stem segment. After several weeks the swelling above the irradiated areas became evident particularly at the higher doses. On Oct. 6th the six trees receiving 2500 or 5000 r were all alive, but at 10,000 r four of five treated trees were dead above, at, and for some distance below the irradiated segment. This higher dosage may have killed the tissue completely, followed by the separation of the bark from the xylem as a result of the overgrowth of the stem above the irradiated area, as shown in Figure 3. The inverted bark produced a similar overgrowth, but without pulling the bark from the stem in the treated segment. At the lower doses of X-rays there was evidence of a phloem block with no death of the stem at the irradiated area.

It is evident that it is possible to produce a phloem block without killing the stem by inverting a ring of bark or by non-lethal exposure of a stem segment to X-rays. In both cases the growth of the treated area is restricted or suppressed. The suppression of growth may be the cause of the phloem block in these cases. According to Abbe and Crafts (1)—"It is characteristic of the sieve tubes of all plants, that, after a brief functioning period — consisting of from a few days in the case of protophloem sieve tubes to a single season in most woody plants — the elements collapse, and death occurs."

The X-ray induction of a phloem block without killing the tissue is apparently due to nuclear injury which prevents continued cell division without killing the cytoplasm. It is known that the cytoplasm is very much more resistant to injury from X-rays than is the nucleus. Thus the sieve tubes already formed could continue to function, but no new ones would be formed to augment and replace those present at the time of irradiation.

The bark inversion also seems to produce a phloem block by the inhibition of cell division. The suppression of growth in the inverted bark rings is apparently due to the inability of nutrients and auxins to move freely against the reversed polarity. There is usually a slight swelling of the top of the inverted bark ring, indicating some diffusion of nutrients, but there is little or no growth of the inverted segment as a whole. Thus the inversion of the bark may check growth by the failure of nutrients to move freely through the inverted phloem tissue.

The new phloem produced at the vertical seam in inverted bark segments appears to be normally polarized since this tissue grows rapidly. Any new phloem tissue produced within the inverted ring of bark should eventually also be normally polarized, but the fact that growth does not occur indicates that few or no sieve tubes are produced, presumably due to the checking of nutrient flow through the inverted segment. The fact that bark inversions made early in the growing season do not survive as well as those made in June and August suggests that some active sieve tubes are needed even though the inverted polarity checks the passage of nutrients and auxins down the stem. Since a tree has lived for five years with a double inverted ring of bark, some material must be transmitted either through the inverted bark or through some other part of the stem.

SUMMARY

A phloem block can be induced without killing the stem tissues by exposing stem segments to X-rays sufficient to suppress cell division or by inverting a ring of bark. The phloem block induced by irradiation appears to be due to the failure of renewal of phloem elements. The reversed polarity of the inverted ring of bark also prevents renewal of phloem elements, presumably by preventing the adequate movement of nutrients and auxins into the inverted phloem cells. The inversion of rings of bark may be modified to produce the degree of dwarfing desired in fruit and ornamental trees.

BUSSEY INSTITUTION AND ARNOLD ARBORETUM,
HARVARD UNIVERSITY

LITERATURE CITED

1. ABBE, LUCY B. and CRAFTS, A. S. Phloem of white pine and other coniferous species. *Bot. Gaz.* **100**: 695-722. 1939.
2. ARGLES, G. K. Stock-scion incompatibility in fruit trees. *Imp. Bur. Fruit Production*. East Malling, Kent, England. 1937.
3. BIDDULPH, O. and MARPLE, J. Translocation of radiophosphorus in the phloem of the cotton plant. *Amer. Jour. Bot.* **31**: 65-70. 1944.
4. BONNER, JAMES. Accumulation of various substances in girdled stem of tomato plants. *Amer. Jour. Bot.* **31**: 551-555. 1944.
5. CHRISTENSEN, ERIC. Root production in plants following localized stem irradiation. *Science* **119**: 127-128. 1954.
6. COLBY, H. L. Stock-scion chemistry and the fruiting relationships in apple trees. *Plant Physiol.* **10**: 483-98. 1935.
7. CRAFTS, A. S. Movement of assimilates, viruses, growth regulators, and chemical indicators in plants. *Bot. Rev.* **17**: 203-284. 1951.
8. DIXON, H. H. Transpiration and the ascent of sap in plants. Macmillan & Co. Ltd. London. 1914.
9. ESAU, KATHERINE. Development and structure of phloem tissue. *Bot. Rev.* **16**: 67-114. 1950.
10. KERR, W. L. A simple method of obtaining fruit trees on their own roots. *Proc. Amer. Soc. Hort. Sci.* **33**: 355-357. 1935.
11. RABIDEAU, G. S. and BURR, G. O. The use of C^{13} isotope as a tracer for transport studies in plants. *Amer. Jour. Bot.* **32**: 349-356. 1945.
12. ROBERTS, R. H. A further trial of ring grafting to produce stock effects. *Proc. Amer. Soc. Hort. Sci.* **33**: 358-359. 1935.
13. ROBERTS, R. H. Theoretical aspects of graftage. *Bot. Rev.* **15**: 423-463. 1949.
14. STRASBURGER, E. et al. *A Textbook of Botany*. Macmillan and Co. Ltd. London. 1898.
15. WEINTRAUB, R. L. and BROWN, J. W. Translocation of exogenous growth-regulators in the bean seedling. *Plant Physiol.* **25**: 140-149. 1950.

DESCRIPTION OF FIGURES

FIG. 1. Baldwin tree, 2 years old, on semi-dwarfing rootstock. A ring of bark was removed and replaced in the normal position on June 1, 1953. This control tree has made considerable growth in a single season.

FIG. 2. Baldwin tree, 2 years old, on semi-dwarfing rootstock. A ring of bark was inverted June 1, 1953. Note dwarfing effect in a single season, and the production of flower buds. The suckering below the inverted ring of bark indicates the checking of auxin flow.

FIG. 3. Baldwin on *M. sikkimensis*, 3 years old, dwarfed by double inverted ring with a slender strip of normal bark on the opposite side of each of the two inverted rings. A short section of normal bark was left between the two inverted rings. This tree bore fruit in its third growing season and bears many flower buds as it begins its fourth year.

FIG. 4. Details of double bark inversion show how phloem transport is checked. The swelling of the upper end of the inverted ring of bark suggests some nutrients and auxins may flow into the inverted bark by diffusion, but active phloem transport is blocked by the reversed polarity of the inverted phloem tissue.

FIG. 5. A poplar stem with inverted ring of bark, showing swelling of the stem above the phloem block imposed by reversed polarity of the phloem.

FIG. 6. A poplar stem exposed to 10,000 r of X-rays. Note the similar swelling of the stem above, and the suckering below, of the irradiated section of stem. The X-rays impose a phloem block by preventing cell division and the renewal of phloem cells. In this case the bark was killed and is pulled away from the wood by the expansion of the stem above the irradiated area, but it is possible to impose a phloem block with X-rays without killing the tissue.

Photographs by Heman Howard.



CONTROL OF TREE GROWTH BY PHLOEM BLOCKS

CRYPTOGAMS OF THE 1948 ARCHBOLD CAPE YORK
(QUEENSLAND) EXPEDITION

P. BIBBY

MUSCI *

LEMBOPHYLLACEAE

Camptochaete brisbanica (C. M.) Broth., Proc. Linn. Soc. N. S. W. 43: 561. 1916.

QUEENSLAND: Mt. Finnegan, *Brass 20058, 20155*, Sept. 1948, alt. 850 m., on branches in rain-forest undergrowth; Mossman River Gorge, *Brass 18173*, Mar. 1948, alt. 150 m., plentiful on granite rocks in rain-forest.

Not compared with the type, but agreeing well with material so named in the National Herbarium of Victoria.

HOOKERIACEAE

Eriopus sp. (aff. *E. apiculatus* [Hk. f. & W.] Mitt.).

QUEENSLAND: Mt. Finnegan, *Brass 20097*, Sept. 1948, alt. 1040 m., trunk of a tree in high mountain forest.

Very close to and probably identical with *E. apiculatus* (Hk. f. & W.) Mitt.

HEPATICAEE

PTILIDIACEAE

Mastigophora Nees

Mastigophora diclados (Endl.) Steph., Spec. Hep. 4: 38. 1909.

QUEENSLAND: Leo Creek, Upper Nesbit River, *Brass 19957*, Aug. 1948, alt. 420 m., cushioned on trees on bank of creek in rain-forest.

LEPIDOZIACEAE

Bazzania S. F. Gray

Bazzania adnexa (L. & L.) Mont., Voy. au Pole Sud. 243. 1842-45.

QUEENSLAND: Lamb's Head, Lamb Range, *Brass 18227*, Mar. 1948, alt. 1000-1100 m., sunny rocks in rain-forest; Mt. Bellenden-Ker, summit of south peak, *Brass 18288*, Apr. 1948, alt. 1550 m., on trees of low forest.

Bazzania Novae-Zelandiae (Mitt.) Kuntze, Gen. Plant. 832. 1901.

* Determined by J. H. Willis.

QUEENSLAND: Mt. Finnegan, *Brass 20144*, Sept. 1948, alt. 1140 m., on bark of a tree in high mountain scrub.

Lepidozia Dumort.

Lepidozia capilligera (Schwaegr.) Lindenb., *Syn. Hep.* 204. 1844.

QUEENSLAND: Iron Range, *Brass 19051*, June 1948, alt. 20 m., on a decaying log in floodplain in rain-forest.

HARPANTHACEAE

Chiloscyphus Corda

Chiloscyphus argutus (R. B. & N.) Nees, *Syn. Hep.* 183. 1845.

QUEENSLAND: Iron Range, *Brass 19052*, June 1948, alt. 20 m., on decaying logs in floodplain rain-forest.

JUNGERMANNIACEAE

Anastrophyllum (Spruce) Steph.

Anastrophyllum piligerum (Nees) Spruce, *Jour. Bot.* 14: 33. 1876.

QUEENSLAND: Mt. Bellenden-Ker, summit of south peak, *Brass 18286*, Apr. 1948, alt. 1550 m., abundant on trees of low forest.

Chandonanthus Mitt.

Chandonanthus hirtellus (Web.) Steph., *Spec. Hep.* 3: 643. 1909.

QUEENSLAND: Mt. Bellenden-Ker, summit of south peak, *Brass 18285*, Apr. 1948, alt. 1550 m., on a tree in low forest.

PLAGIOCHILACEAE

Plagiochila Dumort.

Plagiochila abietine * (Nees.) Lindenb., *Mon. Hep. Gen. Plag.* 134. 1844.

QUEENSLAND: Mt. Finnegan, *Brass 20141*, Sept. 1948, alt. 1140 m., shrub-beries of the summit.

This constitutes the first record of this species on the Australian mainland.

Plagiochilon Hattori

Plagiochilon oppositus (R. B. & N.) Hattori, *Biosphaera* 1: 7. 1947.

Plagiochila opposita (R. B. & N.) Dum., *Rec. d'obs.* 15. 1835.

QUEENSLAND: Mt. Finnegan, growing with *Sticta*, *Brass 20095*, Sept. 1948, alt. 1100 m., on mossy rocks in high mountain.

Not previously reported on the Australian mainland.

* Determined by Th. Herzog, Jena.

SCHISTOCHILACEAE

Schistochila Dumort.**Schistochila cristata** Steph., Hedw. 28: 274. 1889.QUEENSLAND: Mt. Finnegan, *Brass 20089*, Sept. 1948, alt. 1100 m., very abundant on rocks (granite) in high mountain forest.

RADULACEAE

Radula Dumort.**Radula acutiloba** Steph., Hedw. 28: 271. 1889.QUEENSLAND: Leo Creek, Upper Nesbit River, *Brass 19954*, Aug. 1948, alt. 420 m., on dead twigs in rain-forest undergrowth.**Radula buccinifera** (Hk. f & Tayl.) Tayl., Syn. Hep. 261. 1845.QUEENSLAND: Mt. Finnegan, *Brass 20094*, Sept. 1948, alt. 1100 m., on leaves and branchlets of undergrowth in high mountain forest.**Radula reflexa** Mont., Ann. Sc. Nat. 19: 255. 1843.QUEENSLAND: Mossman River Gorge, *Brass 18177*, Mar. 1948, alt. 150 m., moist shady granite rocks in rain-forest.

PLEUROZIACEAE

Pleurozia Dumort.**Pleurozia articulata** (Linb.) Schiffn., Engl. Pflanzenfam. I. 3: 115. 1895.QUEENSLAND: Mt. Finnegan, *Brass 20142*, Sept. 1948, alt. 1140 m., on living twigs in shrubberies of summit; Mt. Bellenden-Ker, summit of south peak, *Brass 18287*, Apr. 1948, alt. 1550 m., hanging from dead twigs in low forest.

FRULLANIACEAE

Frullania Raddi**Frullania Johnsonii** Steph., Hedw. 33: 163. 1894.QUEENSLAND: Mt. Bellenden-Ker, summit of south peak, *Brass 18289*, Apr. 1948, alt. 1550 m., on dead twigs.**Frullania** sp.QUEENSLAND: Summit of Mt. Tozer, Tozer Range, *Brass 19497*, July 1948, alt. 540 m., living branches of *Casuarina* in scrub of summit.

LEJEUNEACEAE

Drepanolejeunea (Spruce) Schiffn.**Drepanolejeunea Micholitzii** Steph. var. *genuina* Herz. Ann. Bryol. 7: 80. 1934.QUEENSLAND: Mt. Finnegan, *Brass 20098*, Sept. 1948, alt. 1040 m., on leaves of undergrowth in high mountain forest.

Drepanolejeunea obliqua Steph., Hedw. 35: 82. 1896.

QUEENSLAND: Mt. Finnegan, associated with *Brass 20144*, Sept. 1948, alt. 1140 m., on bark of a tree in high mountain scrub.

Drepanolejeunea tenuis (Nees) Schiffn., Consp. Hep. Arch. Ind. 280. 1898.

QUEENSLAND: Lamb's Head, Lamb Range, associated with *Brass 18227*, Mar. 1948, alt. 1000-1100 m., sunny rocks in rain-forest.

Physocolea Spruce**Physocolea trichomanis** (Gott.) Steph., Spec. Hep. 5: 912. 1916.

Cololejeunea trichomanis (Gott.) Steph., Hedw. 28: 168. 1889.

QUEENSLAND: Mt. Finnegan, west slopes, *Brass 20054*, Sept. 1948, alt. 850 m., on leaves of an undergrowth tree in rain-forest.

LICHENES**SPHAEROPHORACEAE****Sphaerophorus** Pers.**Sphaerophorus compressus** Ach., Meth. Lich. 135. 1803.

QUEENSLAND: Lamb's Head, Lamb Range, *Brass 18234*, Mar. 1948, alt. 950-1000 m., sunny rocks in rain-forest.

COENOGONIACEAE**Coenogonium** Ehrenh.**Coenogonium implexum** Nyl., Ann. Sc. Nat. 16: 92. 1861.

QUEENSLAND: Speewah, Upper Clohesy River, *Brass 18209*, Mar. 1948, alt. 450 m., trunk of a tree in rain-forest.

CLADONIACEAE**Cladonia** Hill.**Cladonia aggregata** (Sw.) Ach., Vet. Acad. Nya Handl. 16: 68. 1795.

QUEENSLAND: Lamb's Head, Lamb Range, *Brass 18232*, Mar. 1948, alt. 950-1000 m., sunny rocks in rain-forest; summit of Mt. Tozer, Tozer Range, *Brass 19495*, July 1948, alt. 540 m., in shelter of boulders on exposed granite rock faces; Mt. Bellenden-Ker, summit of south peak, *Brass 18290*, April 1948, alt. 1550 m., on peaty ground of a small clearing.

Cladonia verticillata Hoffm. var. **cervicornis** (Ach.) Flot., Linnaea 22: 380. 1849.

QUEENSLAND: Lamb's Head, Lamb Range, *Brass 18233*, Mar. 1948, alt. 950-1000 m., sunny rocks in rain-forest.

PANNARIACEAE

Pannaria Del.

Pannaria myrioloba Muell.-Arg., Bull. d'Herb. Boiss. 4: 92. 1896.

QUEENSLAND: Mt. Bellenden-Ker, summit of south peak, *Brass 18291*, April 1948, alt. 1550 m., on bark of living tree in low forest; Mt. Bellenden-Ker, summit of south peak, *Brass 18292*, April 1948, alt. 1550 m., on dead twigs in low forest.

Pannaria sublurida Nyl., Ann. Sc. Nat. 11: 256. 1859.

QUEENSLAND: Mt. Bellenden-Ker, summit of south peak, *Brass 18293*, April 1948, alt. 1550 m., growing on bryophytes.

COLLEMACEAE

Leptogium S. F. Gray

Leptogium phyllocarpum (Pers.) Mont. var. **isidiosum** Nyl., Syn. Meth. 1: 130. 1858.

QUEENSLAND: Mossman River Gorge, *Brass 18168*, Mar. 1948, alt. 150 m., on rocks on edge of a rain-forest stream.

STICTACEAE

Sticta Schreb.

Sticta aurata Ach., Meth. Lich. 277. 1803.

QUEENSLAND: Mt. Finnegan, *Brass 20359*, Sept. 1948, alt. 910 m., on living bark of an exposed branch in high mountain forest.

Sticta Sayeri Muell.-Arg., Flora 71: 23. 1888.

QUEENSLAND: Lamb's Head, Lamb Range, *Brass 18235*, Mar. 1948, alt. 950–1000 m., sunny rocks in rain-forest.

Sticta sulphurea Schaeer., Moritz. Verz. 127. 1846.

QUEENSLAND: Mt. Finnegan, west slopes, *Brass 20059*, Sept. 1948, alt. 850 m., on a rotting log in rain-forest.

Sticta sp.

QUEENSLAND: Mt. Finnegan, *Brass 20095*, Sept. 1948, alt. 1100 m., abundant on mossy rocks in high mountain forest.

PARMELIACEAE

Parmelia Ach.

Parmelia latissima Fee forma **sorediata** Nyl., Syn. Meth. 1: 380. 1858.

QUEENSLAND: Tozer Range, north end, *Brass 19369*, June 1948, alt. 300 m., exposed granite rocks on summit.

HYMENOLICHENES

THELEPHORACEAE

Dictyonema Agardh

Dictyonema irpicinum Mont., Ann. Sc. Nat. 10: 119. 1848.

QUEENSLAND: Leo Creek, Upper Nesbit River, *Brass 19958*, Aug. 1948,
alt. 420 m., on a mossy log in rain-forest.

NATIONAL HERBARIUM OF VICTORIA,
SOUTH YARRA, VICTORIA,
AUSTRALIA.

ADDITIONAL NOTE ON *NOTHOFAGUS*

C. G. G. J. VAN STEENIS

With one text-figure

THE PAPER on New Caledonian *Nothofagus* by Dr. M. Baumann-Bodenheim alluded to in my revision¹ was preceded by a preliminary note.² Also after a personal interview at Leyden, May 12, 1953, when we again interchanged data, Baumann-Bodenheim still cherished the idea that the New Caledonian representatives of *Nothofagus*, as well as some of those from New Guinea, belong to a distinct genus, *Trisyngyne* Baill., on the single evidence that these species should have "branched caducous ♂ inflorescences," though he later admitted these "inflorescences" were short-twigs. The confusion arises through the fact that the leaf-blades at the base of the flush are often reduced and both the ♂ triads and cupules appear clasped between the stipules. Such a lateral twig in flush may give the superficial impression of an "inflorescence." Morphologically it remains a twig with lateral inflorescences. Whether these short twigs fail to develop further into persistent branches is entirely irrelevant. In the New Guinean species the flowering twigs are usually persistent and not caducous. For these reasons I maintain that the five perfectly good species described by Baumann-Bodenheim belong to *Nothofagus* sect. *Calusparasus* subsect. *Bi-partitae* series *Triflorae* Steen.

The following transfers are therefore necessary:

Nothofagus*Trisyngyne* Baill. *Adansonia* 11: 136. 1873, syn. nov.***Nothofagus codonandra* (Baill.) comb. nov.***Trisyngyne codonandra* Baill. *Adans.* l.c.; Baumann-Bodenheim. *Bull. Mus. Hist. Nat. Paris* II, 25: 420. 1953.***Nothofagus baumanniae* (Baum.-Bod.) comb. nov.***Trisyngyne baumanniae* Baum.-Bod. l.c. 420.***Nothofagus balansae* (Baill.) comb. nov.***Trisyngyne balansae* Baill. l.c. 137; Baum.-Bod. l.c. 420.***Nothofagus discoidea* (Baum.-Bod.) comb. nov.***Trisyngyne discoidea* Baum.-Bod. l.c. 420.***Nothofagus aequilateralis* (Baum.-Bod.) comb. nov.***Trisyngyne aequilateralis* Baum.-Bod. l.c. 421.

¹ Van Steenis, *Jour. Arnold Arb.* 34: 308. 1953.

² Baumann-Bodenheim, *Bull. Mus. Hist. Nat. Paris* II, 25: 419-421. 1953.

Mainly through the generous assistance of Dr. F. Kausel, Santiago de Chile, I obtained some valuable additional material which enabled me to complete my former paper¹ with some interesting illustrations of the



FIGURE 1. *Nothofagus glauca* (Philippi) Krasser. a. Cupule with two lateral nuts, of the central nut only the scar of its attachment is visible. b. A single nut. c. A pair of cupular arms from the exterior showing the sulcate concrescence. d. The cupule without nuts as seen from above, $\times 1 \frac{2}{3}$ (KAUSEL 1319).—*Nothofagus alessandri* Espinosa. e. Cupule seen obliquely from the side, showing the three basal scars and two additional ones at the base of the cupular valves, $\times 4$ (KAUSEL 2303).—*Nothofagus resinosa* Steen. f. Mature nut with reduced cupular valve, $\times 4$ (WOMERSLEY N.G.F. 5134).

cupules of the inadequately known *N. alessandri* Espinosa (fig. 1 e) and *N. glauca* (Phil.) Krasser (fig. 4 a-d).

Another interesting figure is that of the mature nut of *N. resinosa* Steen, from New Guinea, for which I have to thank Mr. J. S. Womersley, Lae. This shows that the reduced elamellar cupule of this species is not appreciably enlarged in fruit.

¹ Van Steenis, Jour. Arnold Arb. 34: 308. 1953.

NEW ZEALAND CONIFERS

VIVIENNE DELLOW CASSIE

With one plate

ONE OF THE MOST DISTINCTIVE ELEMENTS in the New Zealand flora is that formed by the native conifers, which are to be found in almost every scrub and forest community from North Cape to Stewart Island. They are no longer to be found, however, on the outlying islands. There are twenty species, all endemic, distributed among three families in five genera. In size they range from the pygmy pine (*Dacrydium laxifolium*), the world's smallest conifer, which may bear cones at a height of eight centimeters (cf. Cheeseman 1925), to giant kauris and podocarps well above thirty metres. A height of nearly sixty metres has been reported for kahikatea (*Podocarpus dacrydioides*—Entrican and Reid, 1949).

A detailed discussion of the taxonomic features of each species would be superfluous here, since a number of adequate descriptions are already available. These are located in the works of Kirk (1889), Cheeseman (1925), Allan (1929), Cockayne and Turner (1939), Laing and Blackwell (1940), and Dallimore and Jackson (1948). Instead, the relevant literature will be briefly reviewed, although this account does not pretend in any way to be an exhaustive one.

An anatomical basis for taxonomic studies has been adopted by several workers. Seward and Ford (1906) and Eames (1913) have contributed to the knowledge of the Araucariaceae in general and of *Agathis australis* in particular; Eames from a morphological standpoint, the former authors making a broader phylogenetic approach. An early investigation of leaf anatomy of New Zealand conifers was made by Griffin (1907). More recently, a detailed survey of leaf anatomy in *Podocarpus* has been attempted by Buchholz and Gray (1948), and Gray and Buchholz (1951). These authors place the South Pacific species *P. spicatus* and *P. ferrugineus* in a new subsection (*Euprumnopitys*) of the section *Stachycarpus*. The new subsection, *Euprumnopitys*, is distinguished by the absence of idioblasts (i.e. sclerids) in the mesophyll of leaves. Except for *Podocarpus dacrydioides* in the section *Dacrycarpus*, the remaining New Zealand species fall into subsection D of *Eupodocarpus*, based on the absence of accessory transfusion tissue. Geographic distribution of *Podocarpus* has been studied by Foweraker (1934), and later by Buchholz and Gray (1948). The latter regard the Wegener theory of continental drift as the only feasible solution to distribution problems in this genus. There is some evidence from leaf anatomy that migration between Australia-New Zealand and South-Central America may have taken place in both directions (Buchholz and Gray, op. cit., p. 61). *Eupodocarpus* is regarded as the most advanced section because of the hypostomate leaves (stomata con-

fined to the under surface), and the usually prominent accessory trans-fusion tissue. This feature is lacking, however, in subsection D, which contains the New Zealand species. In the section *Stachycarpus*, *Podocarpus spicatus* has the most primitive known arrangement of female cones.

With a view to practical application, Orman and Reid (1941, 1946) have investigated wood anatomy in the genus *Dacrydium*. These workers have constructed a key for the native *Dacrydium* species, using diagnostic features of wood structure. An informative series of bulletins has been published by the New Zealand Forest Service (Ward and Reid, 1949, Entrican and Reid, 1949) on properties and uses of six of the major timber-producing trees in the country (*Dacrydium cupressinum*, *Podocarpus ferrugineus*, *P. spicatus*, *P. totara*, and *Agathis australis*).

Not the least interesting feature of the New Zealand conifers is the prevalence of distinct juvenile leaf forms (Cockayne, 1932). These occur in all species save a few of the podocarps (*P. totara*, *P. hallii*, *P. nivalis* and *P. acutifolius*). Epharmony, too, may cause plants of the same species to have a very dissimilar appearance when grown under different habitat conditions. For example, *Podocarpus nivalis*, a medium-sized bushy shrub in shade and shelter, is reduced to a prostrate shrub with much smaller leaves in direct sunlight (Cockayne, op. cit.).

Hybrids, although not as common as in angiosperm genera like *Hebe* and *Coprosma*, are known or suspected between the following species:*

<i>Podocarpus acutifolius</i> × <i>nivalis</i>	<i>Dacrydium bidwillii</i> × <i>laxifolium</i>
<i>Podocarpus hallii</i> × <i>nivalis</i>	<i>Dacrydium bidwillii</i> × <i>biforme</i> ?
<i>Podocarpus hallii</i> × <i>totara</i> (= <i>P. loderi</i> Cockn.)	<i>Dacrydium biforme</i> × <i>laxifolium</i> ?
<i>Podocarpus hallii</i> × <i>acutifolius</i> ?	<i>Phyllocladus glaucus</i> × <i>trichomanoides</i> ?
<i>Podocarpus ferrugineus</i> × <i>totara</i> ?	<i>Libocedrus bidwillii</i> × <i>plumosa</i> ?
<i>Podocarpus spicatus</i> × <i>totara</i> ?	

Ecological studies are more restricted in number, centering mainly about the kauri (*Agathis australis*). Cranwell and Moore (1936) drew attention to modified growth forms of kauris growing above a height of 660 metres on Te Moehau (Coromandel Peninsula), a refuge of both alpine and subtropical remnants. Further autecological notes have been made by McKinnon (1937, 1940–41), McKinnon and Dumbleton (1935), Harrison-Smith (1938), and Foley (1950). Recently Mirams (1948, 1951, unpubl.) has analysed in detail the environmental factors responsible for growth and regeneration of the kauri. Root nodules of New Zealand conifers were investigated by Yeats (1924).

An important contribution is that of Cranwell (1940), who has described and figured pollen grains of all the New Zealand species, as well as formulating distinctive generic and specific characters according to the peculiarities of each type of pollen grain. Her work indicates that *Dacrydium bidwillii* and probably also *D. biforme* and *D. kirkii* are rightly

* See Cockayne 1932, Cockayne and Allan 1934, Cockayne and Turner 1939.

placed in a group apart from *Podocarpus*, where Sahni and Mitra (1927) would put them, on the basis of the structure of female cones alone. Cranwell (1938) had previously attempted a partial solution of post-glacial vegetation problems through an analysis of pollen from South Island peat beds. Three main periods are recognised:

1. A grassland period correlated with quite uniformly harsh climatic conditions;
2. A warmer and wetter podocarp period;
3. A mosaic of grassland and beech (*Nothofagus*) forest resulting from local climatic differentiation.

The role played by conifers in New Zealand's past geological time has been clarified still further through the work of Harris, Fergusson and Couper (1951). It appears that a number of extinct species, including at least seven podocarps, dominated forest communities between early Cretaceous and Upper Eocene times. Of the present-day species, *Podocarpus dacrydioides* dates from the Oligocene, and *Phyllocladus* is known even earlier from Upper Cretaceous beds.

CLASSIFICATION

The following is an outline classification of the New Zealand species. A revised key to the species and genera occurring in this country has been published previously (Hay and Dellow, 1952).

Araucariaceae

Agathis Salisb.

Agathis australis Salisb. Kauri

Cupressaceae

Libocedrus Endl.

Libocedrus plumosa (Don) Sargent (= *L. doniana* Endl.) Kawaka
Libocedrus bidwillii Hook. f. Kaikawaka, mountain cedar

Podocarpaceae

Podocarpus L'Hérit.

Section: *Stachycarpus*

Subsection: *Euprumnopitys*

Podocarpus spicatus R. Br. Matai, black-pine

Podocarpus ferrugineus D. Don. Miro, brown-pine

Section: *Dacrycarpus*

Podocarpus dacrydioides A. Rich. (FIG. 1). Kahikatea, white-pine

Section: *Eupodocarpus*

Subsection: *D*

Podocarpus totara D. Don. Totara

Podocarpus hallii T. Kirk. Hall's totara, thin-bark totara
Podocarpus acutifolius T. Kirk
Podocarpus nivalis Hook. Alpine totara

Dacrydium Soland.

Dacrydium cupressinum Soland. Rimu, red-pine
Dacrydium kirkii F. Muell. Monoao
Dacrydium biforme (Hook.) Pilger. Pink-pine
Dacrydium bidwillii Hook. f. Bog-pine, mountain pine
Dacrydium colensoi Hook. Silver-pine
Dacrydium intermedium T. Kirk. Yellow silver-pine
Dacrydium laxifolium Hook. f. Pygmy pine

Phyllocladus L. C. Rich.

Phyllocladus trichomanoides Don. Tanekaha
Phyllocladus glaucus Carr. Toatoa
Phyllocladus alpinus Hook. f. Mountain toatoa

BIBLIOGRAPHY

ALLAN, H. H. 1929. New Zealand trees and shrubs and how to identify them. Wellington, N. Z., 188 pp., figs. 1-28.

BUCHHOLZ, J. T. and N. E. GRAY, 1948. A taxonomic revision of *Podocarpus*. I. The sections of the genus and their subdivisions with special reference to leaf anatomy. *Jour. Arnold Arb.* 29: 49-63.

CHEESEMAN, T. F. 1925. Manual of the New Zealand Flora. 2nd. ed., 1163 pp. Wellington.

COCKAYNE, L. 1932. Polymorphy in New Zealand conifers and its relation to horticulture. *Conifers in Cultivation*. Royal Horticultural Society. 151-164, figs. 38-51. London.

COCKAYNE, L., and H. H. ALLAN, 1934. An annotated list of groups of wild hybrids in the New Zealand flora. *Ann. Bot.* 48: 1-55.

COCKAYNE, L., and E. P. TURNER, 1939. The trees of New Zealand, 176 pp., figs. 1-126. Wellington.

CRANWELL, L. M. 1938. Fossil pollens. *N. Z. Jour. Sci. & Tech.* 19: 628-645. figs. 1-9.

CRANWELL, L. M. 1940. Pollen grains of the New Zealand conifers. *N. Z. Jour. Sci. & Tech.* 22 B: 1 B-17 B, figs. 1-7.

CRANWELL, L. M., and L. B. MOORE, 1936. The occurrence of kauri in montane forest on Te Moehau. *N. Z. Jour. Sci. & Tech.* 18: 531-543.

DALLIMORE, W., and A. B. JACKSON, 1948. *Handbook of Coniferae*. 3rd ed., 682 pp. 39 pls., 120 figs. London.

EAMES, A. J. 1913. The morphology of *Agathis australis*. *Ann. Bot.* 27: 1-38.

ENTRICAN, A. R., and J. S. REID, 1949. Properties and uses of Miro, Matai, Kahikatea, Totara, Kauri. *N. Z. Forest Serv. Inform. ser.* 3-7. Wellington.

FOLEY, T. A. 1950. Rate of fall of Kauri (*Agathis australis*) seeds in quiet air, *Forest Research Notes* 1: 32-40.

POWERAKER, C. E. 1934. The distribution of the Podocarpaceae. N. Z. Jour. For. 3: 160-165.

GRAY, N. E., and J. T. BUCHHOLZ, 1951. A taxonomic revision of Podocarpus. V. The South Pacific species of Podocarpus: Section Stachycarpus. Jour. Arnold Arb. 32: 82-92, pls. 1-4.

GRIFFIN, E. M. 1907. The development of some New Zealand conifer leaves with regard to transfusion tissue and to adaptation to environment. Trans. N. Z. Inst. 40: 43-72, pls. VII-X.

HARRIS, W. F., G. J. FERGUSSON and R. A. COUPER, 1951. Unravelling forest history in New Zealand—a symposium. N. Z. Sci. Rev. 9: 5-14.

HARRISON-SMITH, J. L. 1938. The kauri as a host-tree. N. Z. Jour. For. 4: 173-177.

HAY, J. A., and U. V. DELLOW, 1952. New Zealand Conifers. Tuatara 4: 108-117, pls. I-III.

KIRK, T. 1889. The forest flora of New Zealand. 345 pp., pls. 1-142. Wellington.

LAING, R.M., and E. W. BLACKWELL, 1940. Plants of New Zealand, 4th ed., 499 pp., 191 figs. Auckland, London.

MCKINNON, A. D. 1937. On the regeneration of kauri (*Agathis australis*). Collection and germination of kauri (*Agathis australis*) seed. N. Z. Jour. For. 4: 128-129.

MCKINNON, A. D. 1940-41. On kauri growth and yield. N. Z. Jour. For. 4: 293-295.

MCKINNON, A. D., and L. J. DUMBLETON, 1935. The rate of growth of some native trees. N. Z. Jour. For. 3: 224-225.

MIRAMS, R. V. 1948. Some observations on the regeneration of *Agathis australis* Salisb. (Kauri). M.Sc. thesis unpubl. in Auckland Univ. Coll. library.

MIRAMS, R. V. 1951. A study of some of the factors concerned in the natural regeneration of the Kauri (*Agathis australis*). Ph.D. thesis unpubl. in Auckland Univ. Coll. library.

ORMAN, H. R., and J. S. REID, 1940-41. *Dacrydium*. N. Z. Jour. For. 4: 366-367.

ORMAN, H. R., and J. S. REID, 1946. Wood anatomy of New Zealand *Dacrydium* species. N. Z. Jour. For. 5.

SAHNI, B., and A. K. MITRA, 1927. Notes on the anatomy of some New Zealand species of *Dacrydium*. Ann. Bot. 41: 75-89, pl. VII, figs. 1-4.

SEWARD, A. C., and M. F. FORD, 1906. Araucariae, recent and extinct. Trans. Roy. Soc. London, Ser. B, 198: 305-411, pls. 23 & 24, figs. 1-28.

WARD, W. C., and J. S. REID, 1949. The properties and uses of Rimu. N. Z. Forest Serv. Inform., Ser. No. 2. Wellington.

YEATS, J. S. 1924. Root nodules of New Zealand pines. N. Z. Jour. Sci. & Tech. 7: 121-124.

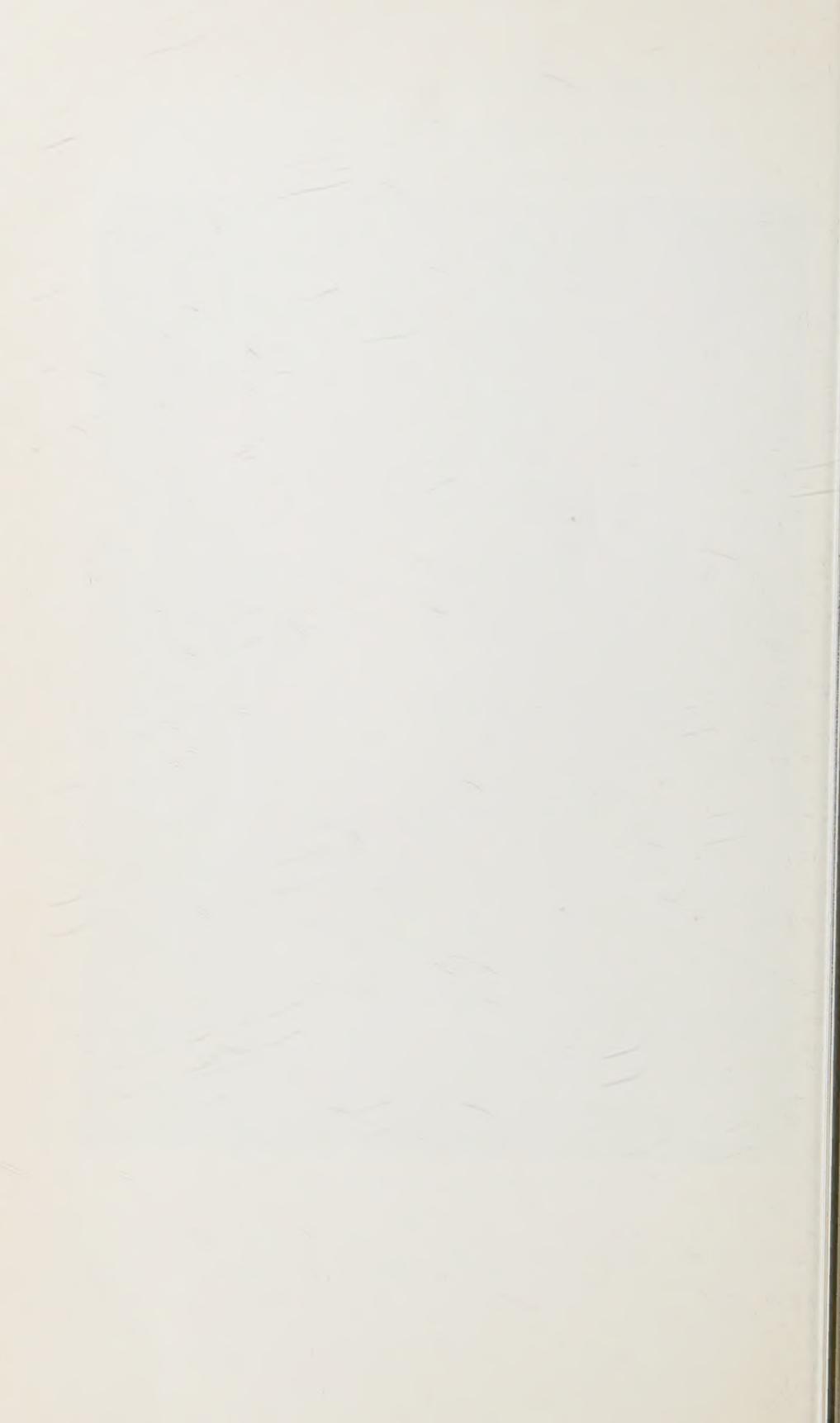
WELLINGTON, NEW ZEALAND.

PLATE I

Podocarpus dacrydioides A. Rich. growing in beech (*Nothofagus*) forest about 620 metres above sea level, near Lake Waikaremoana, New Zealand.



PODOCARPUS DACRYDIOIDES A. RICH.



RECENT PUBLICATIONS OF THE
ARNOLD ARBORETUM

JOHNSTON, I. M. <i>The Botany of San Jose Island (Gulf of Panama)</i> . Sargentia VIII. Pp. 1-306, with seventeen plates and two text-figures. April 22, 1949.	\$6.00
REHDER, ALFRED. <i>Bibliography of Cultivated Trees and Shrubs</i> . Pp. i-xl. 1-825. 4°. June 14, 1949.	\$20.00
MERRILL, ELMER D. <i>Index Rafinesquianus</i> . Pp. i-vi, 1-296. 4°. August 8, 1949.	\$10.00

Make checks payable to the ARNOLD ARBORETUM.